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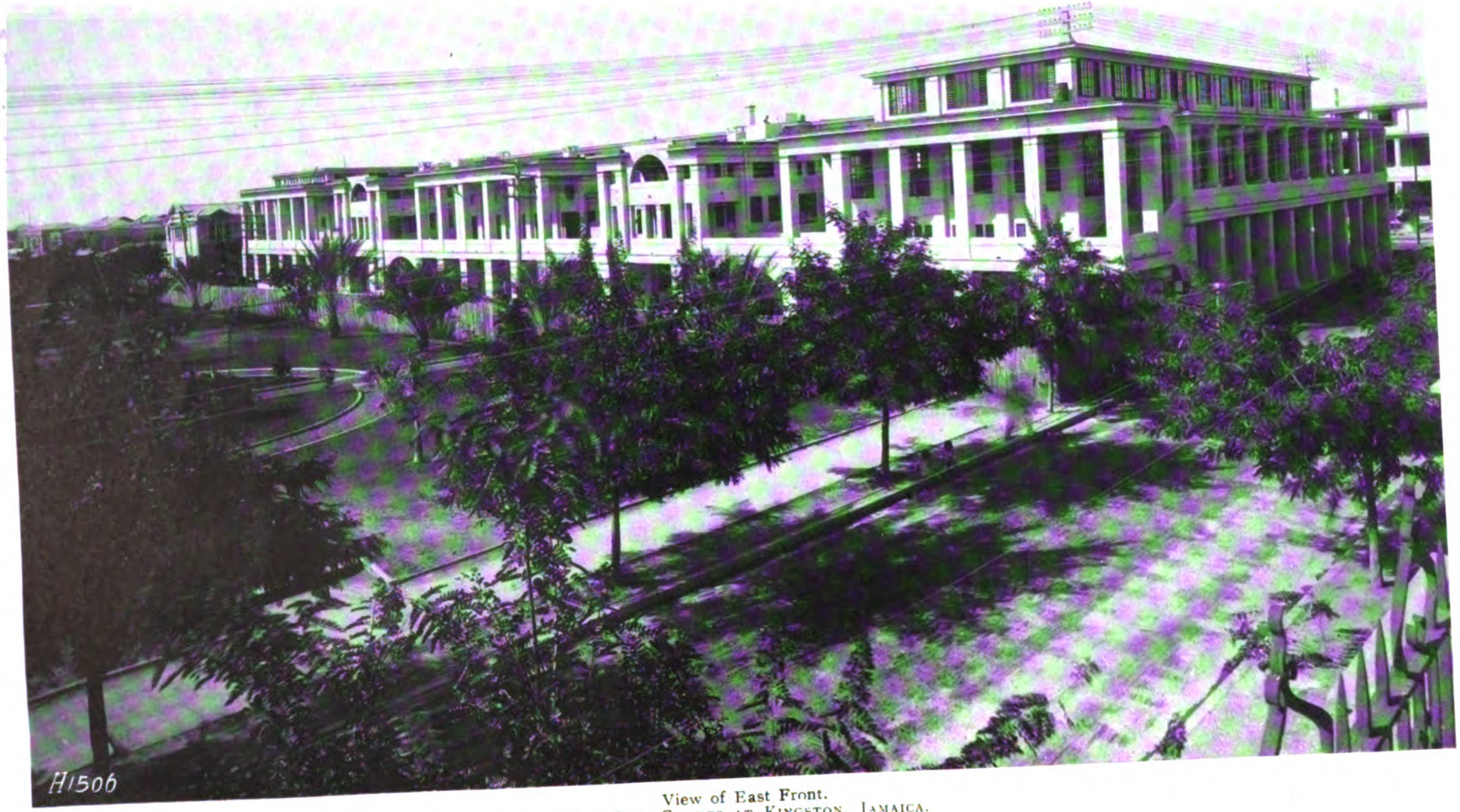


View of East Front.
NEW LAW COURTS AT KINGSTON, JAMAICA.
(For Description see p. 40.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume IX. No. 1. LONDON, JANUARY, 1914.

EDITORIAL NOTES.

CONCRETE COTTAGES.

In accordance with the announcement contained in our December number, our present issue contains the Conditions of our Competition for obtaining suitable designs for cheap concrete cottages. (See page 3.)

These conditions have been most carefully framed with a view to obtaining the best possible results.

It is not necessary here to enter again into details regarding the premiums offered, etc., as these points were raised in our editorial columns last month and are fully set out in the Conditions.

Sufficient emphasis cannot be laid on the great national importance of this question of the better and healthier housing of our industrial and rural population, and every effort made in this direction should call for attention and consideration. That the Authorities and the public are fully alive to this all-important matter is evinced by the reports and articles contained in our daily Press and from the numerous letters we have received on the subject. We therefore hope that a large number of competitors will enter for this competition.

In conclusion, we would draw attention to another article we are publishing, in which we have reprinted the recommendations contained in a Report recently issued by the Departmental Committee appointed to inquire and report as to Buildings for Small Holdings in England and Wales, and which should be useful to intending competitors.

IMPORTANT REINFORCED CONCRETE WORKS DURING THE PAST YEAR.

In the past year considerable progress has again been shown in the use of reinforced concrete for public buildings at home and in our colonies, and anyone who has perused our journal during the last twelve months will have realised on what important buildings this form of construction is now being used economically and with quite practical results.

As pioneers in the advocacy of the use of reinforced concrete, we cannot but emphasise again the value of this material, particularly for buildings that are simple and straightforward in plan and of considerable area. For such buildings the advantages are considerable, and we hold that all public departments and municipalities should follow the very excellent example of H.M. Office of Works, in adopting reinforced concrete in the interests of the public purse. As far as the municipal authorities are concerned, certain progress has been made in obtaining longer loan periods for buildings in which reinforced concrete has been used, and although this progress is a step in the right direction, we should have liked it to have gone further, but we have no doubt the Local Government Board will gradually develop a more modern policy.

We would only point again to our current pages to show the varied uses of reinforced concrete, our articles this month including such important works as the Extensions to the British Museum, the Jamaica Law Courts, and the structures demanding such exceptional requirements as the Mappin Terraces at the Zoological Gardens.

£125 CONCRETE COTTAGE COMPETITION.

The object of this journal is to contribute to the solution of the great rural housing problem of the day, and thus the following competition has been organised.—ED.

THE Proprietors of CONCRETE AND CONSTRUCTIONAL ENGINEERING invite competitive designs for suitable detached or semi-detached labourers' cottages. The materials to be used shall be largely or mainly concrete in some form. It is to be assumed that the cottages would be erected in one of the Home Counties of England (at least 30 miles from Charing Cross, London), at a prime cost to the owners of £125 per cottage. The Competition is open to all persons residing in the British Empire, and the following premiums are offered :—

First Prize	*One Hundred Guineas.*
Second Prize	*Fifty Guineas.*
Third Prize	*Twenty-five Guineas.*
Fourth and Fifth Prizes	*Ten Guineas each.*

The Assessors appointed by the Proprietors are :—

Mr. Max Clarke, F.R.I.B.A.
Professor Beresford Pite, F.R.I.B.A.
Mr. Edwin O. Sachs, F.R.S.Ed.

The following are the conditions of the Competition :—

CONDITIONS OF THE COMPETITION.

1.—The object of this competition is to obtain a design suitable for a detached or semi-detached labourer's cottage that can be erected at a prime cost to the owner of £125 when put up in a series of six in one of the Home Counties on a site at least thirty miles from Charing Cross, the owner buying his materials and employing labour without the intervention of a third party.

2.—Concrete is to be the primary building material used in the construction of these cottages, and solid concrete, reinforced concrete, concrete blocks or hollow blocks, concrete partition slabs, or any other suitable form of concrete will be acceptable. Lintols, sills, hearths, sinks, etc., are to be taken in concrete or artificial stone. Slates or tiles, if used, shall preferably be cement slates or cement tiles. Thatch, wood shingles, etc., are not permissible for roofing. Freedom from the usual restrictions of current bye-laws, etc., will be granted with the view of securing up-to-date practice.

3.—It is understood that the cottages will be erected on adjoining sites, each measuring 65 ft. frontage by 200 ft. deep, the front of the site being on the east side of a 50-ft. main road running north to south and having a frontage line set back 27 ft. from the boundary. No fencing or paths or land drainage are to be included for in the £125. Ground taken out for foundations shall be spread at the back of the site. The subsoil is clay.

4.—It is understood that there is no main drainage or gas supply, and that there is a local water-supply service, but the £125 shall *not* include for a water supply to the house connected to the public water service or for any plumbing or sanitary work or equipment; but the necessary equipment shall be shown in the drawings, including a length of 40 ft. of 4-in. drain in the direction of a cesspool located at the back of the building, and the w.c., the sink, etc., shall be shown in connection with the drain leading to the cesspool.

5.—There will be no restriction as to the number or character of the rooms, excepting as follows:—

(*a*) The principal living-room (or parlour) shall not have a less area than 150 ft. sup., and the principal bedroom shall have a superficial area of not less than 125 ft. sup.

(*b*) The entrance (outer door) of the building to the kitchen or living-room shall be an indirect entrance, and not a direct entrance.

(*c*) The accommodation shall be for two adults, two male and two female children.

6.—There is no restriction as to whether the cottage should be a one-storey building or comprise a ground floor and a first floor.

7.—All plans shall preferably be drawn on not more than one sheet of white Whatman or Cartridge paper, size 27 in. by 20 in., mounted on cardboard or on strainers, so as to be exactly 28 in. by 21 in. over all, but two sheets will be accepted.

The drawings to be in black lines only; the plans, elevations, and sections to be to a scale of ⅛ in. to the foot, details ½ in. to the foot, and the site plan 1-32 in. to the foot. All shading or the like to be done in hatching, sectional parts on plans and sections, where the material is of concrete, to be tinted in light Prussian blue, and no other tints or variation of ink or greys or the like are permissible.

If more than one sheet is used, all ⅛-in. scale plans, at least one section, the front elevation, and the table referred to in Clause 11 shall be together on one sheet. All drawings shall stand on the sheets with their base paralleled to the 27-in. edge of the sheet.

One detail at least shall be given, namely, that of an External Wall.

A line perspective is optional, but shall not occupy more than 8 in. by 6 in. of the paper.

8.—All the writing on the drawings shall be in plain black block letters, the capitals not less than ¼ in. in size and the small letters in proportion.

The "headings" of the sheets to be in capitals not less than ¾ in. high.

Names shall *not* be used on any of the rooms, but the following abbreviations shall be applied:—

E	Main entrance.
H	Hall, lobby, or anteroom (if any).
K	Kitchen.
P	Living-room or parlour (if any).
KP............	Combined living-room and kitchen (if any).
Sc	Scullery or wash-house (if any).

B	Bedroom.
Bt	Bathroom (if any).
L	Larder or food-store (if any).
C	Cupboard or closet (if any).
W	W.C.
d	Dresser (if any).
c	Copper (if any).
s	Sink.
b	Bath (if any).
m	Manhole

9.—In every room there shall be plainly written its superficial area in feet in black ink. All numerals shall be in plain block numbering not less than $\frac{1}{8}$ in. in size.

10.—The beds for the inmates shall be shown in dotted lines, 6 ft. by 2 ft. 9 in. for each adult and 5 ft. 6 in. by 2 ft. 6 in. for each child.

11.—On the sheet showing the plans there shall be a list (table) of the rooms with their two principal dimensions, their superficial area, their height, and their cubic contents. The rooms shall be named in the same order as in Clause 8.

12.—On the sheet on which the plans are drawn there shall be given the cubic contents of the building measured from the bottom of the footings up to half the height of any sloping roof, or to 1 ft. above any flat roof. In the case of rooms a portion of which is formed by a sloping roof the dimensions shall be taken up to half way between the ceiling of the room and the apex of the roof.

13.—All usual structural fittings have to be provided for in the price of £125, including a kitchen range, fireplaces, mantels, but not the w.c., sink, copper, or bath.

14.—Accompanying the sheet or sheets of drawings there shall be the following descriptive specification, typewritten (with a margin of not less than $1\frac{1}{2}$ in.) one side of the paper (foolscap size), and arranged as follows :—

Page 1: Description of the building and any remarks of the competitor.

Pages 2 and 3: Short specification, with an exact description of the concrete intended to be used, and a specification of its method of execution.

Page 4: List of fittings, etc., and the net prime cost prices at which they have been taken.

Page 5: An exact statement of how the competitor himself arrived at the cost, data, measurement from plans, etc. Such statement, however, to exclude anything like a bill of quantities. This specification shall be strongly fastened together at the left-hand top corner.

15.—Strict adherence to the conditions to be aimed at. The assessors will be strictly guided by the limits of cost.

16.—Regarding architectural treatment, there shall be no unnecessary features or ornaments, preference being given to simplicity of treatment and avoidance of fads in joinery and glazing.

17.—The whole of the designs will be exhibited in London. Delivery to take place at the registered offices of Concrete Publications, Ltd., North British and Mercantile Building, Waterloo Place, Pall Mall, London, S.W.

18.—The designs to which premiums are awarded shall become the property of the proprietors of Concrete and Constructional Engineering.

19.—The drawings shall be sent in between May 1st, noon, and *May 15th, noon* (1914) ***latest.***

20.—The decision of the assessors shall be final.

21.—Should the proprietors of CONCRETE AND CONSTRUCTIONAL ENGINEERING be able to arrange, as they anticipate, for the erection of one or more cottages, according to any of the premiated designs for which an inclusive prime cost estimate not exceeding £125 can be obtained, they will endeavour to have the author or authors employed to superintend the erection at an inclusive fee of 10 per cent. on the estimate for the first cottage, and 3 per cent. on any further ones, or some other form of remuneration which shall be over and above any premium awarded by the assessors.

22.—Competitors are not limited to one design, but each design shall be presented on a separate sheet or sheets, and shall rank as an entirely separate entry.

23.—All drawings submitted, excepting those to which premiums have been awarded, will be returned to the competitors upon application at dates to be announced in the public Press.

24.—No motto or device shall be added to any drawing or specification, but with every set of drawings and specification handed in there shall be presented in a plain foolscap envelope a bona fide statement that the design presented is wholly the personal work of the author, and this plain foolscap envelope (containing the full name and address inside) shall have no superscription or distinguishing mark of any kind whatsoever on the outside. All the designs and specifications will be numbered by the promoters in order of receipt.

NOTES.

The following literature may be of use to would-be competitors:—

(*a*)—Earlier copies of CONCRETE AND CONSTRUCTIONAL ENGINEERING, which give useful information and examples of concrete cottages and similar buildings, can be seen at the principal architectural libraries or are obtainable from the publisher at 1s. each (or post free 1s. 3d.), and they are as follows:—

Concrete Houses for the United States. (November 1907, page 353.)
A Village Hall Constructed in Concrete. (November 1907, page 402.)
A Concrete Industrial Village. (December 1909, page 513.)
Reinforced Concrete for Farm Buildings. (December 1909, page 516.)
Concrete Blocks for Building Purposes. (March 1910, page 212.)
Cottages at Newbiggin Made of Concrete Blocks. (September 1910, page 688.)
Reinforced Concrete Bungalows. (October 1910, page 769.)
Cheap Cottages in Agricultural Districts. (December 1910, page 909.)
Concrete House at Glencoe, Ill., U.S.A. (March 1911, page 230.)
Concrete Block House on Gidea Park Estate. (June 1912, page 471.)
Reinforced Concrete Buildings at Rowntree's Cocoa Works. (July 1912, page 528.)
Concrete Block Houses on the Gidea Park Estate. (August 1912, page 633.)
Concrete Block Cottages at Talbot's Inch, Kilkenny. (October 1912, Frontispiece, and page 785.)
Concrete Agricultural Cottages in Norfolk. (October 1912, page 732.)
Concrete Block Cottages, Kilkenny. (November 1912, page 854.)
Concrete Cottages. (April 1913, page 288.)
Concrete Cottages in South Wales. (September 1913, page 643.)
Concrete Blocks and Tiles in Norfolk. (November 1913, page 789.)

(*b*)—Would-be competitors can obtain, upon written application, post free, a book entitled "Cement Uses" from the Associated Portland Cement Manufacturers (1900), Ltd., Portland House, Lloyd's Avenue, E.C., which gives useful information as to modern concrete practice.

(*c*)—Some useful information as to cottages is contained in a Report recently issued and entitled "Report of the Departmental Committee on Buildings for Small Holdings in England and Wales" (Official Abstract reprinted from the Parliamentary Paper [Cd. 6708], 1s. 6d., obtainable from Messrs. Wyman and Sons, Fetter Lane, London, E.C.).

EXTENSIONS TO THE BRITISH MUSEUM, LONDON.

REINFORCED CONCRETE IN THE NEW KING EDWARD VII. GALLERIES.

Some very interesting structural work has been executed in connection with the extensions to the British Museum, which affords another striking example of the advantages of reinforced concrete.—ED.

INTRODUCTION.

It is pleasing and interesting to know that in a building of such high importance as the new Galleries at the British Museum, which are to be associated permanently with the memory of His late Majesty King Edward VII., reinforced concrete has been used to a very considerable extent in the internal construction. Due consideration was given to the sound and fire-resisting properties of the structure to be erected and the Expanded Metal systems of construction were adopted.

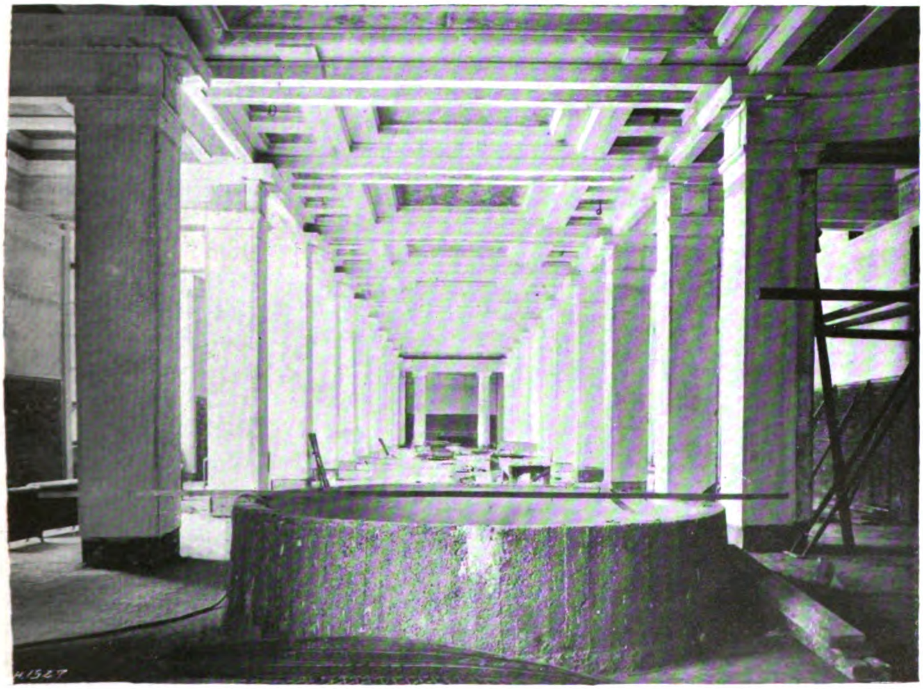


Fig. 1. View showing Ceiling, etc., to Ground Floor Gallery,
EXTENSIONS TO THE BRITISH MUSEUM, KING EDWARD VII. GALLERIES.

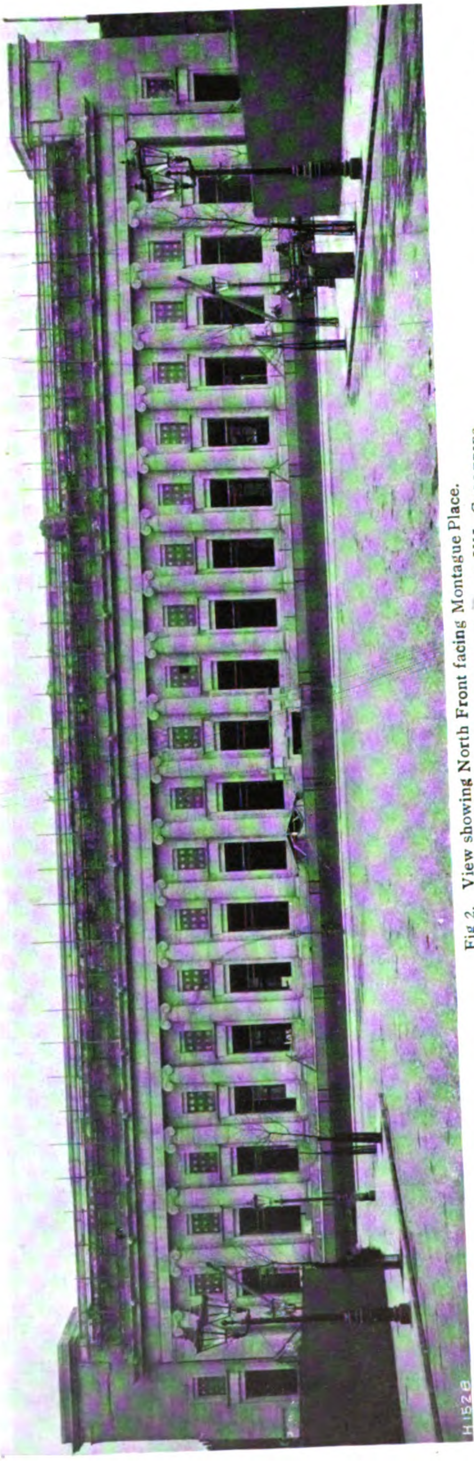


Fig 2. View showing North Front facing Montague Place.

EXTENSIONS TO THE BRITISH MUSEUM, KING EDWARD VII. GALLERIES.

The work comprises the King Edward VII. Galleries facing Montague Place, and the reconstructed North Library forming a connecting block between the new and the old buildings. The new wing forms an extension to the north side of the Museum and is the first portion of an extensive scheme embracing the south, east, and west sides.

The new building is approximately 320 ft. long by 50 ft. wide and 80 ft. high from street level to the top of the parapet wall. The foundation stone was laid in June, 1907, and, as will be seen from *Fig.* 2, the work is now nearing completion. This illustration also shows that the north front is treated in the Ionic order in Portland stone; there are twenty Ionic columns which start 14 ft. above street level.

FLOORS.

There are four suspended reinforced concrete floors:—Sub-ground floor at entrance level from Montague Place; ground floor; Mezzanine floor; and top gallery floor with roof over. *Fig.* 3 shows some of the structural steelwork, and typical temporary timbering and expanded steel reinforcement in position ready to receive the concrete flooring. At their respective levels the floors are supported by built-up steel

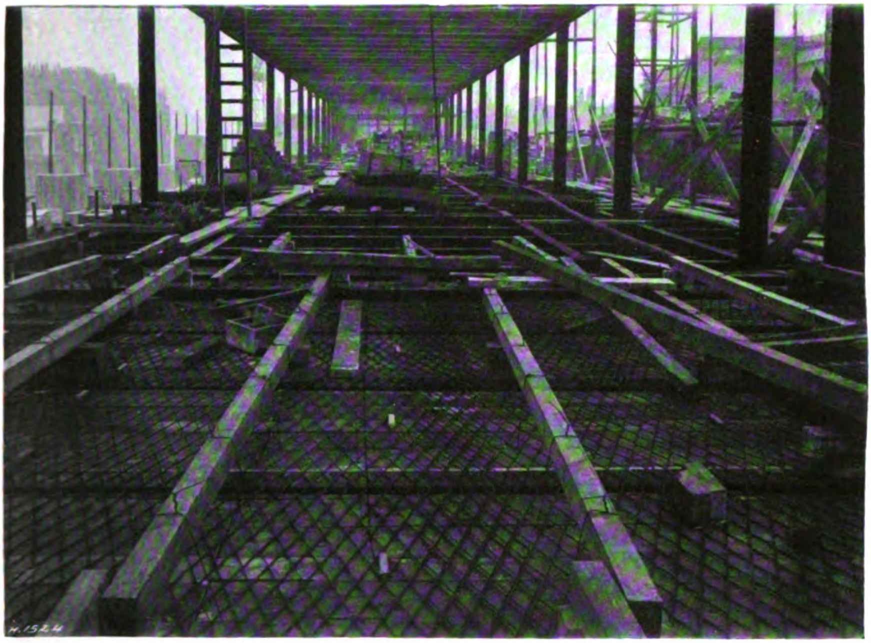


Fig. 3. Showing Reinforcement and Temporary Timbering to Flooring.

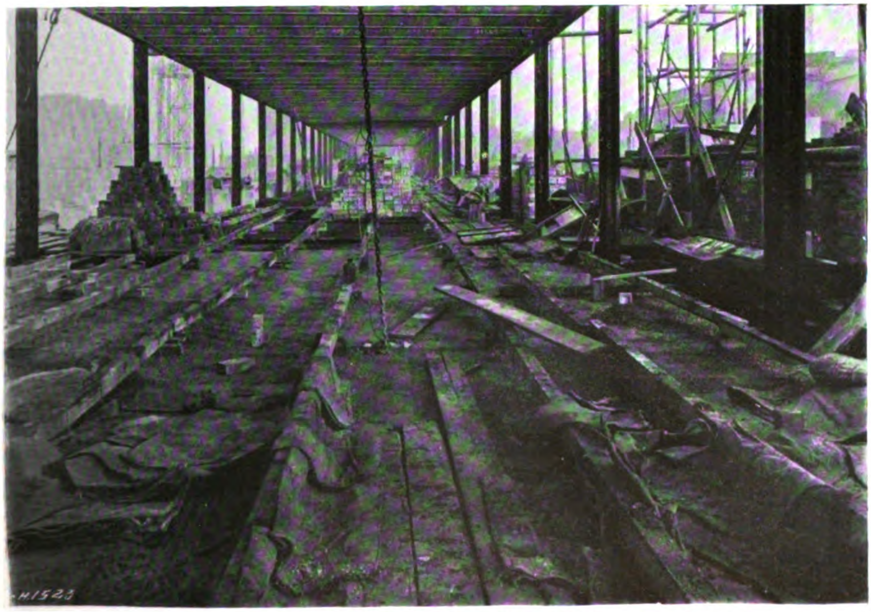


Fig. 4. View showing Reinforced Concrete Flooring.
EXTENSIONS TO THE BRITISH MUSEUM, KING EDWARD VII. GALLERIES.

stanchions, set at 16 ft. 8 in. centres longitudinally, on which rest longitudinal R.S.J. mains carrying R.S.J. secondaries at 4 ft. 2 in. centres. The centre longitudinal bay is 25 ft. 6 in. wide, the two side longitudinal bays varying in width as the main walls diminish in thickness towards the roof. *Fig.* 4 shows

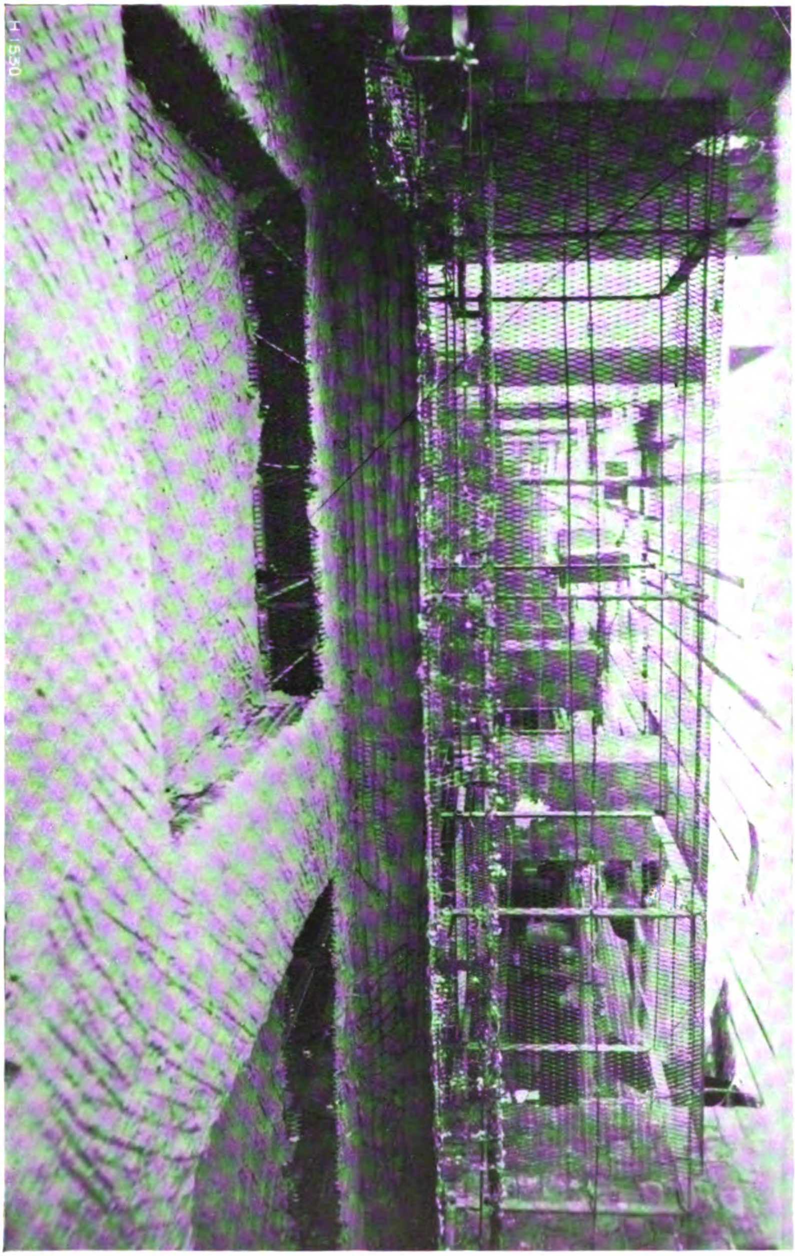


Fig. 5. View showing Typical Details of Mock Beam Construction.
Extensions to the British Museum, King Edward VII. Galleries.

some of the reinforced concrete flooring laid and with its top left to receive sand and cement bedding for the surface finishes.

The steel stanchions are encased in 9 in. brickwork coated with lime and hair plaster finished in lime putty; the R.S.J. mains and secondaries are encased in concrete, splayed down from the flooring to the bottom flanges.

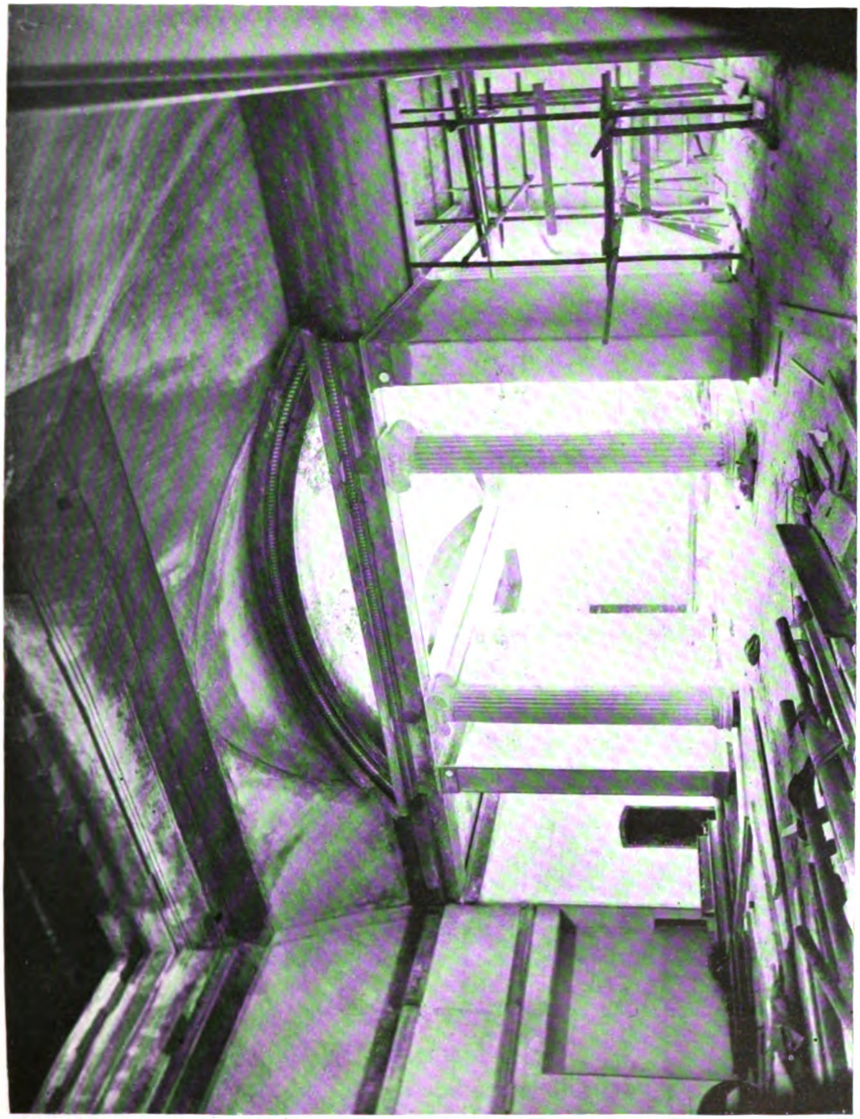


Fig. 6. View showing Ceilings to Top Gallery.
Extensions to the British Museum, King Edward VII. Galleries.

The soffit of the flooring is $\frac{1}{2}$ in. below the top flanges of the secondaries, and as the reinforcement is laid on top of the secondaries it is thus embedded ½ in. from the underside of the concrete flooring.

All the floors are 4 in. thick and they are reinforced throughout with No. 8, 3-in. Diamond Mesh Expanded Steel.

Due consideration was given also to the question of the floor surface finish to be used. In the first place, wood block flooring was chosen as a finish for the ground, top gallery and the north library floors, but it was discarded in favour of cork plates, fastened down by a special preparation of bitumen laid on sand and cement bedding, 2 to 1, 2½ in. thick. The sub-ground and the Mezzanine floors in the galleries and the floor to the students' room over the north library are finished with cork carpet, ¼ in. in thickness, laid on sand and cement bedding. It was necessary to have the sand and cement bedding 2½ in. thick, otherwise the finished floor levels allowed for wood block surface would not have been maintained.

In order to obtain the best possible resistance to sound and fire, consistent with economical construction, the upper floors are provided with an air space between them and the ceilings below.

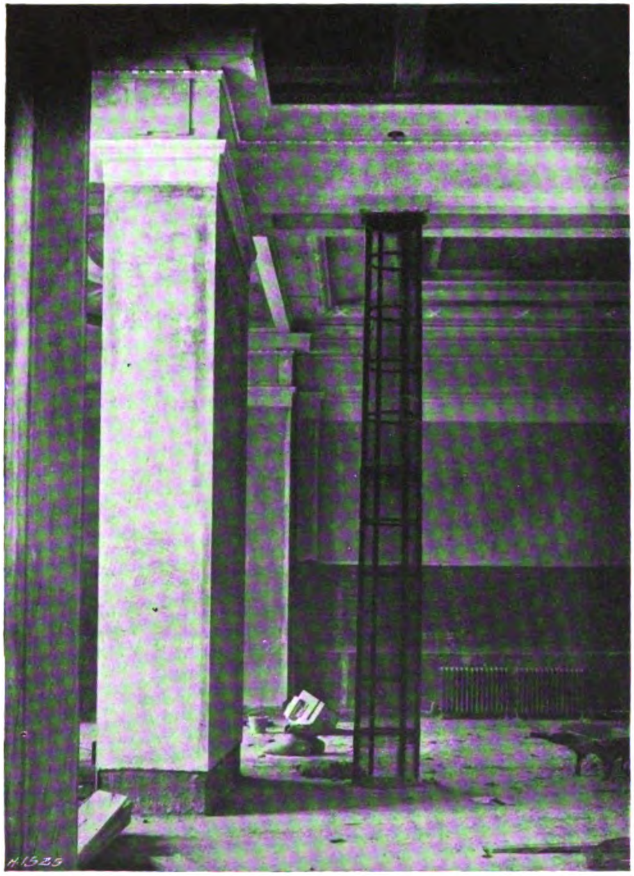


Fig. 7. • Details of Construction of Mock Columns in Galleries.
EXTENSIONS TO THE BRITISH MUSEUM, KING EDWARD VII. GALLERIES.

CEILINGS.

The ceilings to the sub-ground and the Mezzanine floors are flat and plain, and are of Expanded Metal Lathing and plaster, suspended beneath the R.S.J.'s in the flooring by means of flat mild steel bars spaced 12 in. apart, hung on edge in mild steel hangers carried by mild steel clips fixed to the bottom flanges of the R.S.J.'s.

In the ground floor gallery, which is intended for the exhibition of glass and ceramics, and in the north library the ceilings are suspended in a similar way, but they are ornamented with mock beams, sunk panels, cornices, etc., as shown in *Fig.* 5. The metal grounds of the mock beams, etc., consist of flat mild steel bar cradles, bent to the necessary shape and fixed 3 in. apart to the R.S.J.'s in the flooring, and straight round mild steel rods, set 12 in. apart along the cradles and wired to them, to act as stiffeners for the Expanded Metal Lathing, which is wired to the rods and around the shaped cradles.

The Expanded Metal Lathing and plaster ceiling to the top gallery is suspended by means of clips, hangers, bars, etc., from the steel roof trusses above. It is curved and ornamented, and as prints and drawings are to be exhibited in this gallery, the ceiling is designed for and fitted with roof-lights.

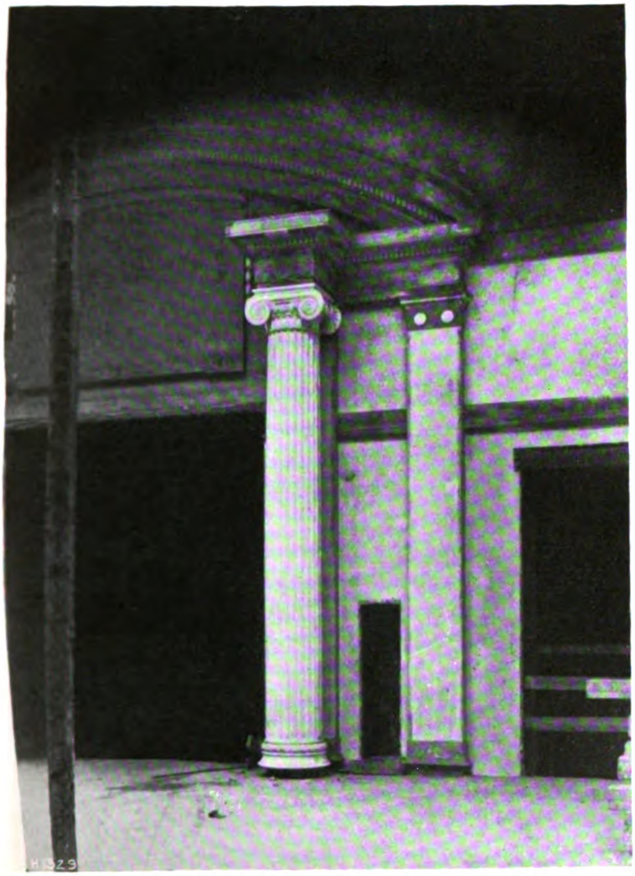


Fig. 8. Details of Construction of Mock Columns in Galleries.
EXTENSIONS TO THE BRITISH MUSEUM, KING EDWARD VII. GALLERIES.

MAIN STAIRCASE.

The main staircase with its landings is of reinforced concrete framed in rolled steel sections; it is primarily the means of access to the galleries, and is the central feature of the general scheme, particularly at the top, where the lift grille is enriched with the Royal Arms in cast iron gilded and lacquered.

The treads and risers were constructed *in situ* in concrete, reinforced with 3 in. Diamond Mesh Expanded Steel embedded about $\frac{1}{2}$ in. from the soffit, which is flush and finished in Keene's cement. The balustrade also is formed in reinforced concrete, marble facings are fixed on the treads and risers and on the balustrade. The balustrade to the circular light well on the ground floor gallery, shown in the foreground in *Fig.* 1, is also of reinforced concrete faced with marble.

The four steel columns in the staircase and the six in the north library are made of steel angles, riveted together with flat bar rings, filled in solid with and encased in reinforced concrete.

MOCK COLUMNS.

Figs. 7 and 8 show clearly how the mock columns in the galleries were constructed; they are formed of small steel angles, riveted together with flat bar rings, with Expanded Metal Lathing wired to them and covered with sand and cement 3 to 1, 3 in. thick.

ROOF TRUSSES, ETC.

The built-up steel trusses carrying the roofing and the suspended ceiling to the top gallery are encased in reinforced concrete.

At the roof level on the Montague Place elevation there is a reinforced concrete parapet wall.

Over the radiators in the north windows on the ground floor level, shelving was constructed in sand and cement 2½ to 1, 2 in. thick, reinforced near each face and covered in marble $\frac{5}{4}$ in. in thickness.

GENERALLY.

The concrete throughout was composed of 3½ parts of crushed clinker, 1½ parts of fine clinker, and 1 part of Portland cement; the plaster throughout on expanded metal lathing was composed of three parts of lime and hair mortar to one part of Portland cement, finished in Keene's cement; the concrete is nowhere less than 2 in. thick and the plaster nowhere less than ¾ in. thick. Clean fresh water only was used for mixing purposes.

The galleries have been erected to the plans and specifications and under the supervision of the architect, Mr. John James Burnet, LL.D., A.R.S.A., F.R.I.B.A.

The Expanded Steel reinforcement for concrete work and the Expanded Metal Lathing for plaster work used throughout was supplied by the Expanded Metal Company, Limited, of London and West Hartlepool.

Messrs. W. E. Blake, Ltd., of London and Plymouth, are the general contractors for the undertaking, and they have carried out the whole of the work described in this article except the cork flooring finishes and the lift grille.

CONCRETE IN SMALL DOMESTIC BUILDINGS.

From a Report of the Departmental Committee appointed to Inquire and Report as to Buildings for Small Holdings in England and Wales.

In view of the competition we are instituting, and regarding which particulars will be found in another part of this issue, the extracts given below may be of interest and use to those entering for the competition.—ED.

IN recent numbers of this journal we have dwelt on the question of cheap cottages, and we have pointed out that the possibilities of concrete for this purpose have not yet been quite realised. In the Report of the Departmental Committee for Small Holdings, which was issued recently, considerable space is devoted to the use of concrete for cheap cottages, and we give below the parts of the Report relating to this all-important question:—

CONCRETE.

116. We have made careful inquiry into the value of concrete for structural purposes in connection with small holdings. We have inspected examples of concrete construction in its various forms, including solid and hollow blocks, monolith and reinforced concrete, and we have had before us a witness who has specialised in work of this nature. We have also endeavoured to ascertain what economy, if any, was effected by using concrete instead of brick, and whether any special circumstances accounted for its use in particular instances. At the same time we have kept in view the question of the suitability of the material for the purposes of dwelling-houses, and the relative degree of comfort secured by its use.

117. Concrete has not been used so extensively in England and Wales as in some other countries; in fact, it may be said scarcely to have been used at all for the building of small houses, except in the form of concrete blocks. Moreover, there are at present very few architects or builders who have devoted much attention to its employment for building cottages.

Comparison of the cost of concrete construction with that of brick is somewhat difficult, owing partly to the fact that concrete work is usually carried out under conditions differing from those applying to the equipment of small holdings. For example, it is seldom adopted unless there is a group or block of houses to be erected, whereas houses on small holdings are usually isolated, or at most built in pairs. It is possible, of course, to estimate what brick construction would cost under circumstances similar to those in which concrete is used, and this is done in most of the following instances, which, with the exception of the last, are examples of some of the concrete houses that we have inspected:

(i.)	County	Essex.
	Number and construction of houses.	20. Concrete blocks, tile roof.
	Cubic contents . . .	11,500 cubic feet.
	Cost	£162, or 3·4d. per cubic foot.
(ii.)	County . . .	Essex.
	Number and construction of houses.	Several semi-detached. Concrete blocks, Eternite slate roof.
	Cubic contents . .	9,600 cubic feet.
	Cost	£155, or 3·9d. per cubic foot.
	Remarks	About ¼d. per cubic foot cheaper than brick. Some have been built for 3¼d. per cubic foot.
(iii.)	County	Northumberland.
	Number and construction of houses.	120 at present. Concrete blocks, Eternite slate roof.
	Cubic contents . . .	11,000 cubic feet.
	Cost	£127, or 2·8d. per cubic foot.
	Remarks	The aggregate for the concrete cost practically nothing. The cost per house includes a due allowance for depreciation and working expenses of the plant for mixing the concrete and making the blocks, but nothing for roads. Estimated saving, as compared with brick, £15 per house.
(iv.)	County	Devon.
	Number and construction of houses.	46 and two shops. Concrete blocks, Eternite slate roof.
	Cubic contents (average) .	10,900 cubic feet.
	Cost	£167, or 3·7d. per cubic foot.
	Remarks	Fine granite chippings were close at hand. The saving, as compared with brick, was stated to be 6d. per yard super. for labour and mortar alone. Haulage 1¼ miles up bad roads.
(v.)	County	Glamorgan.
	Number and construction of houses.	5. Concrete *in situ*, reinforced concrete roof.
	Cubic contents . . .	7,630 cubic feet.
	Cost	£100, or 3·1d. per cubic foot.
	Remarks	Slag from local steel works costs only 1s. 6d. per cubic yard on site. No sand was required. Estimated cost in brick, £130.

It will be seen that some saving is claimed to have been effected by the use of concrete, but apart from the fact that its cheapness is partly explained by the presence of suitable materials in the vicinity, or by other exceptional circumstances, it is clearly unsafe to conclude that the economy effected on a large contract could equally well be secured if only a few houses were to be erected. On the contrary, it is improbable that concrete can compete at present with brick, especially in a district where bricks are cheap, unless a fair number of houses are to be erected.

118. There are numerous patents for reinforcing concrete, but in general these patent methods are expensive, and there is the further drawback that the firms supplying patent reinforcements do not themselves carry out the construction, so that resort must be had to ordinary builders and contractors for the actual building of a house. If a large and experienced firm from a distance be employed on a small contract the expense may be prohibitive, while, if a local builder be employed, the absence of technical knowledge, and the difficulty of ensuring a proper specification and adequate supervision, make it almost impossible to achieve a satisfactory result.

119. In the case of a large building scheme, however, there is little doubt that in many districts of England and Wales a substantial saving could be effected by the use of concrete. If the pecuniary advantage to be derived from its employment in place of brick depends to any extent upon the concentration of a large amount of work within a small area, it is obvious that the fullest economy could only be secured, so far as the equipment of small holdings is concerned, where the circumstances permitted of a considerable number of holdings being provided together on a large estate. This system of development is so much to be recommended on other grounds that the necessity of resorting to it, if concrete construction is to be carried out as cheaply as possible, cannot in itself be regarded as an obstacle to the wider use of this material, assuming that its constructional suitability is established.

Whatever opinion may be held as to the practicability of utilising concrete on any extensive scale in connection with the equipment of small holdings, it cannot be doubted that there are likely to be great developments in concrete construction, and, in spite of all the difficulties that exist at present in securing a reliable result with single buildings of concrete erected under ordinary rural conditions, we have seen enough examples to convince us that efforts should be made to develop the use of this material. We propose, therefore, to give some details of the various modes of construction to which concrete is adapted.

METHODS OF CONCRETE CONSTRUCTION.

120. Concrete may be used for building in the following ways:—

(i) It may be moulded into blocks or slabs, and these used for building in much the same way as blocks of stone; we have seen many cottages that were built in this way.

(ii.) It may be filled in between wood sheeting, thus forming a monolith structure built up *in situ*. A number of the Hollesley Bay cottages were built economically in this manner, as the cost of the sheeting was distributed over several houses.

(iii.) It may be poured in a more liquid state into wood or iron moulds erected complete to the form of the building. This method has been adopted by Mr. Edison for his "poured cottages."

(iv.) It may be filled into moulds laid horizontally, each mould producing one side of the building; these moulded slabs, when set, are put together to form the cottage. This method was described to us by a witness, the main points of whose evidence are given on p. 19.

(v.) It can be used as reinforced concrete, in which case bars or rods of iron or steel are used to take up the tensile strain. Such reinforcement can be used more or less with all the above methods.

CONCRETE BLOCKS.

121. This method of construction is the one which we have found to be most commonly adopted. It is the simplest, and the existence of various machines for turning out blocks on a large scale makes this system easier of adoption than methods which involve more continuous supervision as the work of construction proceeds; for this reason, perhaps, it is the method which

gives the most uneven results. We inspected a considerable number of houses built on this system, and nearly always found that wet had driven through the walls; in some few instances the blocks were so porous as to make the houses unfit for habitation. We also found that the majority of the houses inspected showed a tendency to develop vertical cracks, extending the whole height of the walls, not only through the joints, but across the blocks themselves; these cracks increased the difficulty of securing a dry interior. In fairness, however, to the builders of some of the concrete-block houses that we saw, and in defence of the method itself, it must be added that we inspected one example of a number of such houses which were entirely satisfactory, the houses being pleasing in appearance, well-proportioned (a result not always easy to achieve in handling a unit so large as the ordinary concrete block), free from cracks, and thoroughly dry inside.

122. In building houses of concrete blocks, it is important that the lengths of the walls and the sizes of the openings for door and window frames should be, so far as possible, exact multiples of the size of the blocks. The actual design of the concrete block has not been thought out so well in this country as in the case of a patent block used in Sweden, which provides for almost continuous air space. Hitherto blocks have usually been moulded with an air space in the centre, the inner and outer portions being connected at the ends. If the concrete is porous damp is likely to strike through these solid portions; for this reason, the method of laying double slabs on edge so as to form a wall with a continuous cavity is being adopted in some places, and this method, if the work is carried out properly, is calculated to ensure a dry wall, even with concrete that is slightly porous. If, however, double slab walls are necessary in order to obtain a satisfactory result, there cannot be much economy, in ordinary circumstances, in such a wall as compared with brickwork.

CONCRETE IN SITU.

123. In the second method it is usual to leave openings into which door and window frames are inserted subsequently. For simple work, such as the foundations of farm buildings, this method is the best and most economical, but for a wall that is to be carried up any considerable height, as in the case of a two-storied house, the cost of framing and sheeting is heavy. Even if several houses are to be erected close together, so that one set of sheeting may suffice for them all, the cost of re-erection is considerable; at Hollesley Bay it was estimated, in the case of a one-storey cottage, that the cost of building upon this method was about equal to that of a 9-in. brick wall with bricks at 30s. per 1,000 delivered on the site.

MOULDED CONCRETE.

124. In the third method, the door and window frames may be placed in position in the mould, and the concrete is then poured round them. Mr. Edison has invented a system whereby an iron mould of the whole house is set up, and the building made by pouring the liquid concrete in at the top of the mould, the house thus becoming a complete monolith. By this method all joints are avoided, and it is claimed that a house can be finished in a fortnight. Since, however, the mould alone costs about £1,200, it is quite clear that it could only

be profitably employed if a large number of houses of identical pattern were to be erected in close proximity. A French firm that has made use of some such mould claims that a saving of from 20 to 30 per cent. can be effected, but we have no evidence to show how far this claim can be substantiated.

HORIZONTAL MOULDS.

125. In the fourth method each side of the building is cast in a horizontal mould, thus forming a large slab, which is raised into a vertical position when it has set. The mould is very simple and inexpensive to make, as it is only necessary to lay a level staging, for which purpose the floor or roof boards can be used. The door and window frames are laid on this staging and the mould completed. Its horizontal position facilitates the arrangement of the reinforcing rods, and it is not necessary to make an upper side to the mould, as the concrete can be evenly spread and screeded off to the required thickness. A house at Letchworth was erected upon this system some years ago by the city engineer of Liverpool, clinker from the refuse destructor being used for the aggregate. The method of construction was described to us by a witness, who has adopted it for the erection of one or two buildings, and reference may be made to the Abstract of Evidence (page 74) for detailed particulars.

126. With all the different methods of construction, in addition to any saving effected in the actual cost of the concrete wall, as compared with one of brickwork, there is usually a considerable reduction in the cost of plastering, as a slight skimming coat is all that is required; indeed, it is possible in many cases to smooth-trowel the surface of the concrete as it sets, so that colour-wash may be applied direct without any plastering.

CONCRETE FLAT ROOFS.

127. The witness already referred to has also succeeded in making concrete flat roofs perfectly waterproof. It is true that the work is of comparatively recent date, but it has been completed long enough for defects to show themselves if any were likely to appear. There can be no doubt that if further experience confirms the evidence that a flat roof of concrete 3 in. thick, without any covering, can be made thoroughly watertight, such a roof would be considerably cheaper than any form of slate or tile roof. It was stated by the witness that a saving of £15 per house could be effected, and we have been given figures showing an actual saving of £11 on the roof of a cottage with dimensions 37 ft. by 16 ft. 9 in. as compared with the cost of an ordinary hip or pitch roof of flat tiles.

Some further experience is needed to determine whether there would not be a liability to excessive condensation with solid walls and roofs not more than 3 in. or 4 in. in thickness.

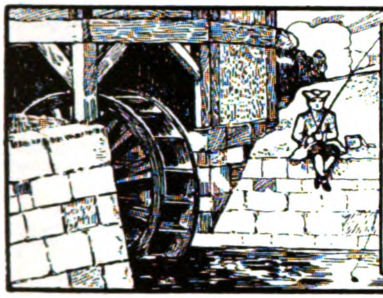
MATERIALS AND HANDLING.

128. Whatever be the form of concrete construction adopted, or the nature of the work, the success of the result will depend on the use of suitable materials and their careful mixing. Waterproof concrete can only be made by using a thoroughly impervious aggregate, and so grading it that the interstices between the larger fragments may be entirely filled with smaller particles and clean sand; the function of the cement is then simply to bind the

whole together. While bricks and other porous materials may make excellent concrete for fireproof purposes, or for ordinary foundations, they are not suitable for external walls or roofs, where waterproof properties are essential. For such purposes an aggregate of granite or gravel is best; clean slag or clinker may also be used if it can be relied upon to contain no impurities such as free sulphur or partially burnt material.

We are convinced that the need for building concrete walls hollow is due to the faulty work that so often results from the use either of an unsuitable aggregate, or, what is equally disastrous, defective cement; and that if the fullest economy is to be obtained by the use of concrete, it will only be by the adoption of careful and intelligent methods by which this necessity may be avoided.

129. The Engineering Standards Committee has fixed a standard specification for cement, and none which fails to comply with the British standard specification for Portland cement should ever be used where it is desired that the concrete shall be waterproof. This cement is usually supplied in three grades—viz., quick, medium, and slow-setting. Detailed instructions on the most scientific method of using cement of the quality known as British Standard, and of mixing concrete for various purposes, are issued by the Royal Institute of British Architects and by the Concrete Institute.



REINFORCED CONCRETE PANORAMA, ZOOLOGICAL GARDENS.

By ALBERT LAKEMAN.

This work is quite unique, and as an example of reinforced concrete construction there is nothing in existence which in any way resembles the problem which has herein been dealt with, and in consequence it has much interest to those who study the various applications of this material.—ED.

THE scheme described in this article is the outcome of a bequest by the late Mr. Mappin, who provided a sum of money to defray all the expenses in connection with the work.

The primary object of the panorama is to show the animals in such a manner that they appear in a state as nearly as possible resembling the natural, and avoid the caged appearance which is generally associated with animals kept in captivity. The architects for the scheme are Messrs. Belcher and Joass, and it will be seen in *Fig.* 2 that the plan is that of a quadrant, and this

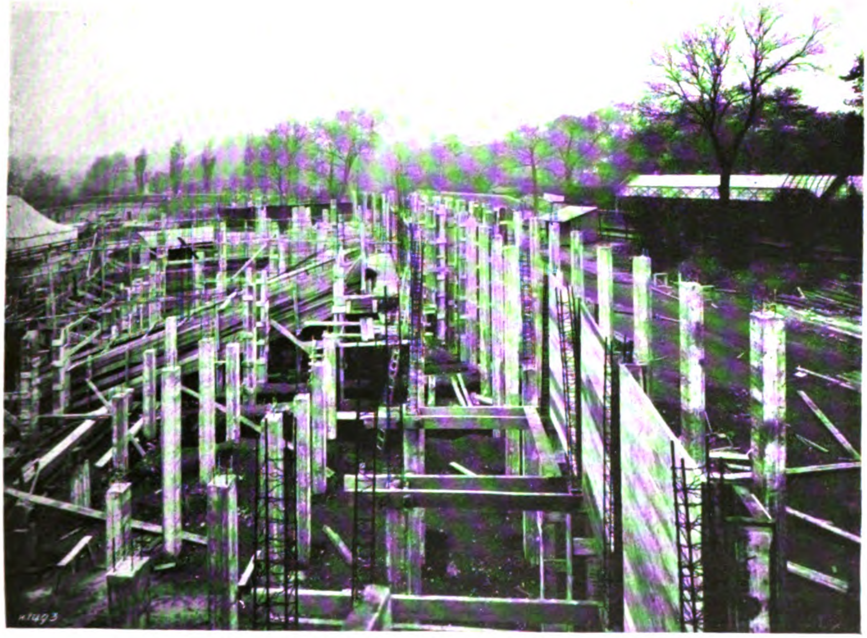


Fig. 1. View showing Columns under Construction.
REINFORCED CONCRETE PANORAMA, ZOOLOGICAL GARDENS.

has a radius to the extreme outside of about 288 ft., thus the whole scheme covers an area of about 260,000 sq. ft.

The panorama is divided up by three terraces for visitors, and these are at varying levels with a wide flight of steps at either end for the passage from one level to the other. The centre of the quadrant will be occupied by a tea-house, adjacent to which is the lower terrace, and immediately on the other side of the terrace a large duck-pond is being formed. Between the duck-pond and the middle terrace there are four large enclosures for deer. A reinforced concrete wall separates the latter from the terrace, and on the other side of the terrace there is a large dry ditch which is formed to prevent the bears from jumping out of the enclosures which occur between the middle and upper terraces. There are six large bear enclosures, and each of these contains a water tank in which the animals can disport themselves, while the surface of

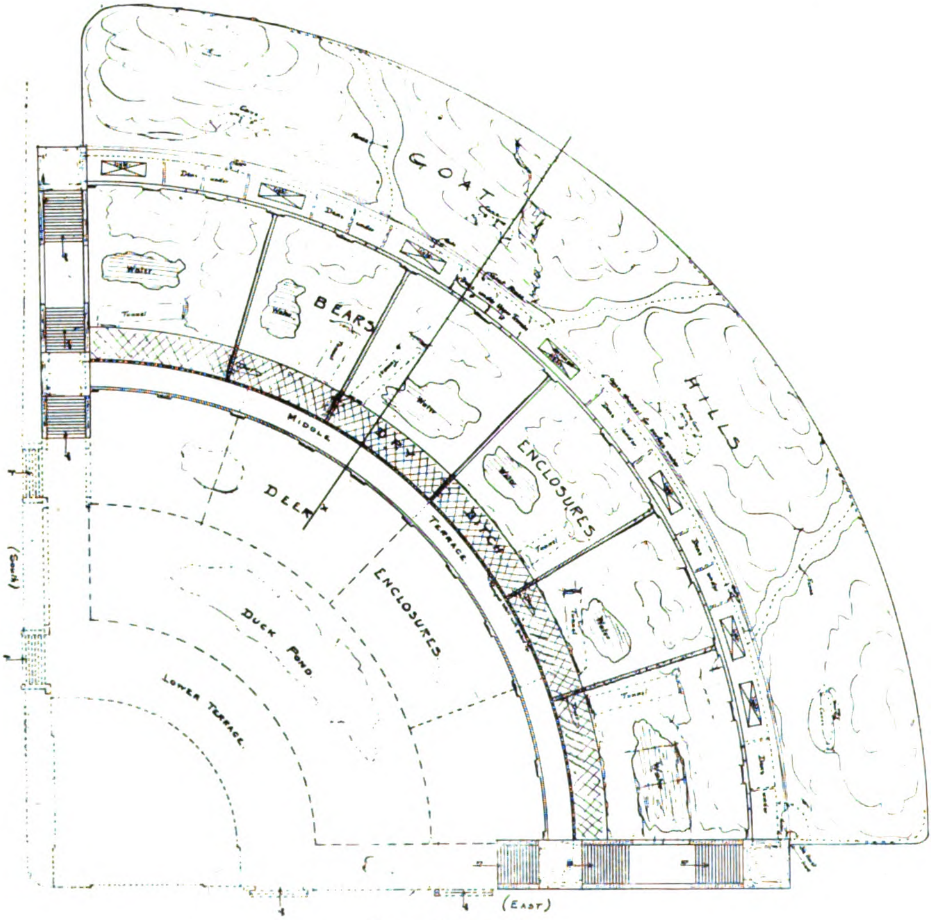


Fig. 2. General Plan.
Reinforced Concrete Panorama, Zoological Gardens.

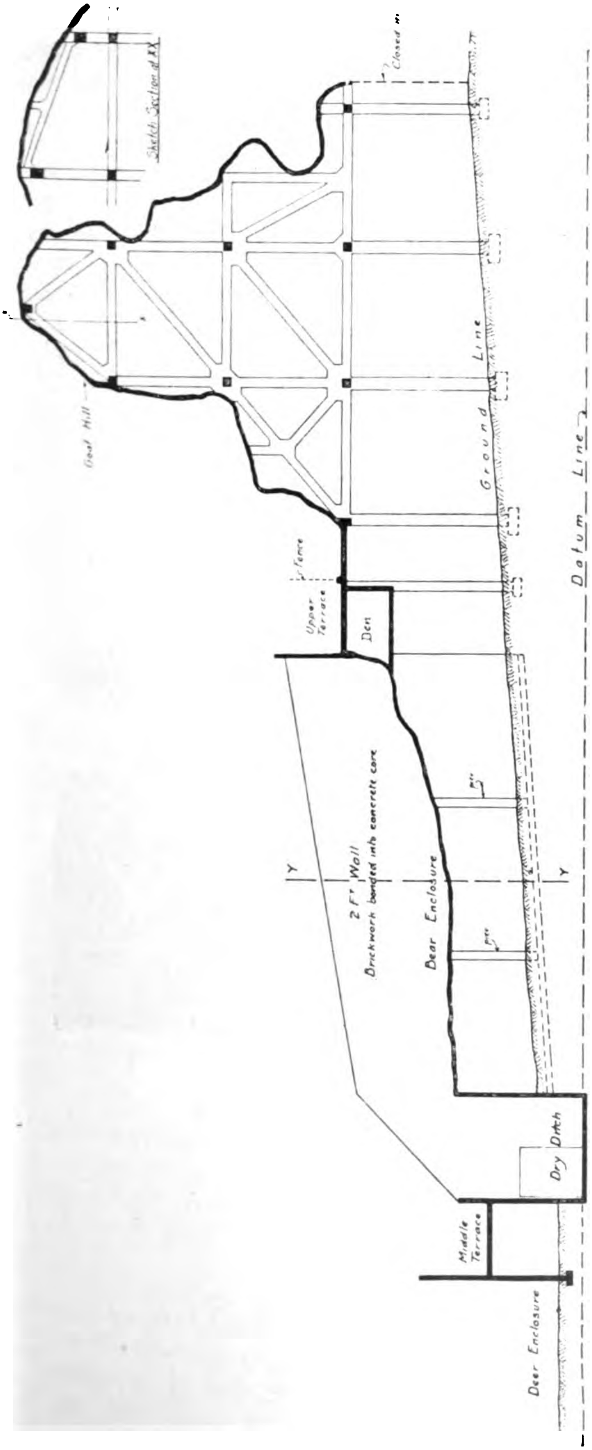


Fig. 3. Cross Section.

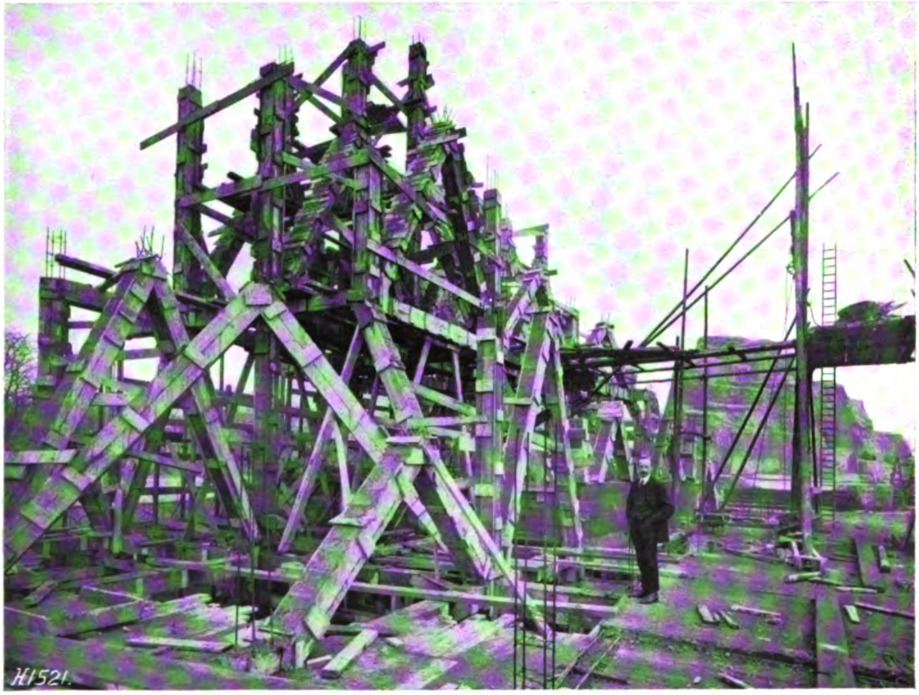
Reinforced Concrete Panorama, Zoological Gardens.

the enclosure is undulating and constructed to resemble natural rocky ground as far as possible. The upper terrace separates the bear enclosures from the goat hills, which are quite one of the most striking features of the scheme, these rising up to a height of about 70 ft. from the ground level and being grouped to form four distinct hills.

These hills are shown in outline in the section in *Fig.* 3, which indicates somewhat the uneven nature of the surface and shows the difficulty of the bracing for such an irregular contour. The photograph in *Fig.* 4 gives a general idea of this bracing under construction, while one of the finished hills can be seen in the distance, although the full height is somewhat lost, as the view is taken from the middle terrace and not from the ground level.

The section in *Fig.* 3 also shows the dens for the bears, which are constructed under the upper terrace. The bear enclosures are separated from each other by high division walls, which are formed with concrete having a surface which is just as it leaves the centering, and a rustic effect is obtained by the use of wire netting, which has allowed the concrete to bulge. At the same time great care and thought has been devoted to the work in order to avoid any projections which would enable the bears to climb up the walls and escape. The slabs in the bear enclosure are illustrated in *Fig.* 5, and it will be seen that the thickness varies from 5 to 7 in.

No beams in the ordinary sense of the word could be formed owing to the irregular surface of the slab, but these were formed in the same thickness by the introduction of additional bars for a width of about 2 ft. 6 in., and these beams followed the same lines as the slabs. The reinforcement in the latter consisted generally of ¼-in. bars at 10-in. centres in one direction, ⅜-in. bars at about 3¼-in. centres in the opposite direction. Some of the bars are turned up and passed over the beams, as shown, and stirrups are also provided. The columns were also made of different heights, and the centering for the slabs was formed partly with planking and partly with wire netting, the latter being allowed to sag and thus assisting in the formation of the undulations.



Photograph by Ernest Milner.] [*London, S.W*

Fig. 4. Bracing to Second Goat Hill.
REINFORCED CONCRETE PANORAMA, ZOOLOGICAL GARDENS.

The water tanks in these enclosures form interesting examples of reinforced concrete, as they are generally suspended from the columns and slabbing, and are formed with a very irregular shape, as will be seen in the photographic view in *Fig.* 7, which shows the underside of one tank. Despite the fact that no particular precautions were taken with the

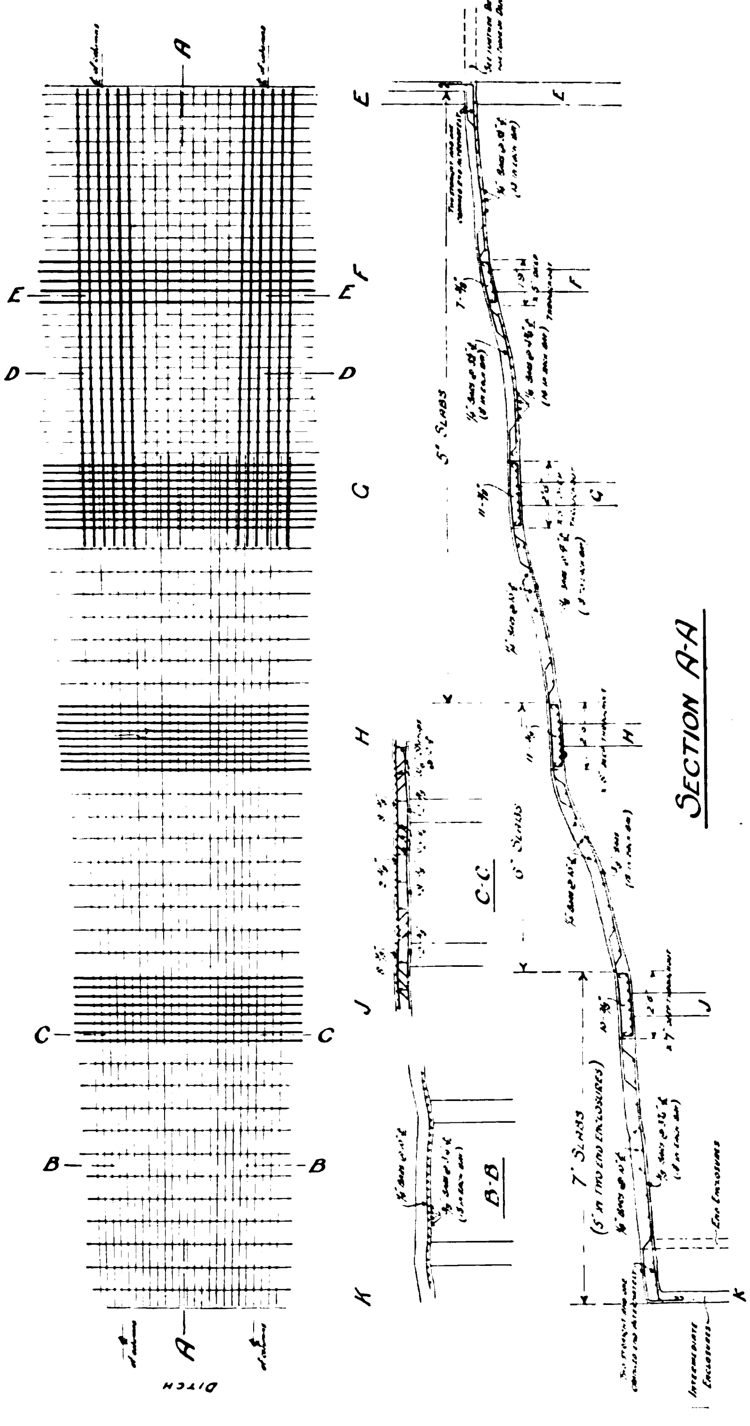
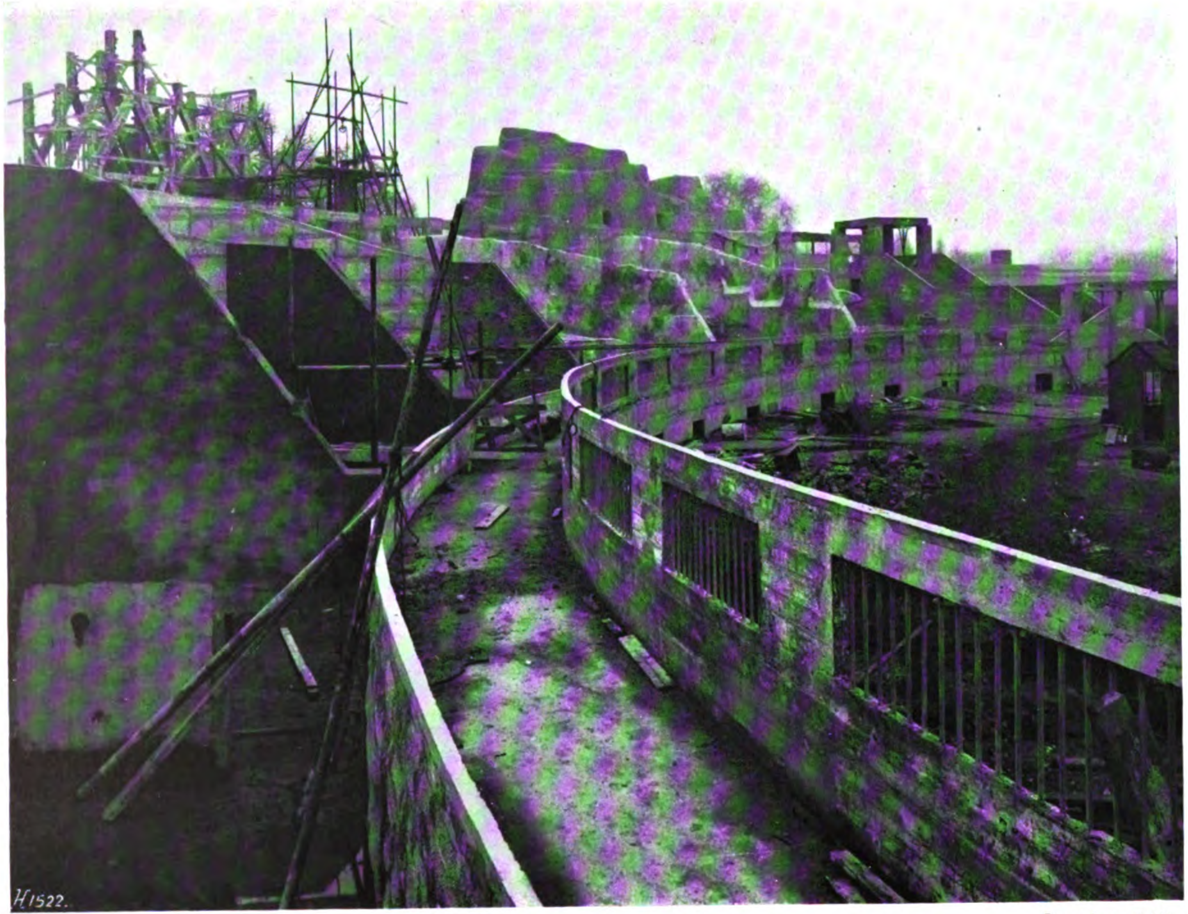


Fig. 5. Detail of Slabs in Bear Enclosures.
REINFORCED CONCRETE PANORAMA, ZOOLOGICAL GARDENS.

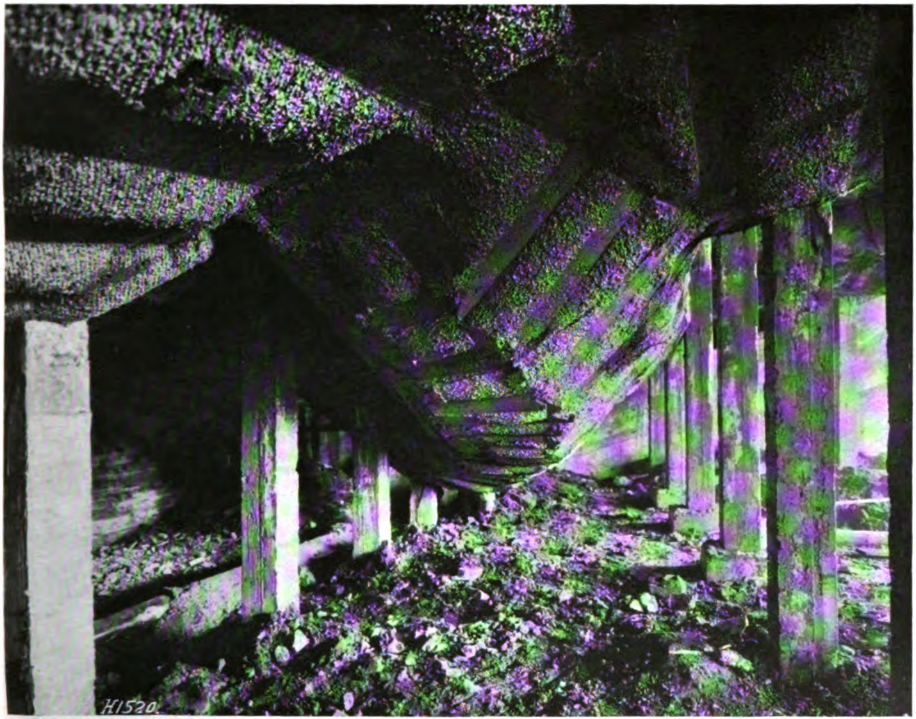


Photograph by Ernest Milner] [London, S.W.

Fig. 6. General View of Bear Enclosures and finished Goat Hill.
REINFORCED CONCRETE PANORAMA, ZOOLOGICAL GARDENS.

work, these tanks have been found to be perfectly watertight, and it will be understood that there was some difficulty in tamping the concrete when portions of the supporting centering were composed of wire netting only. The largest tank is that formed in the extreme eastern enclosure, which will be occupied by the polar bears, and this has a maximum length of about 40 ft. and a width of about 17 ft., with a depth of water of 6 ft. This tank is fitted at the deep end with four observation windows 2 ft. by 1 ft. 6 in., through which the bears can be seen when under water and their movements noted.

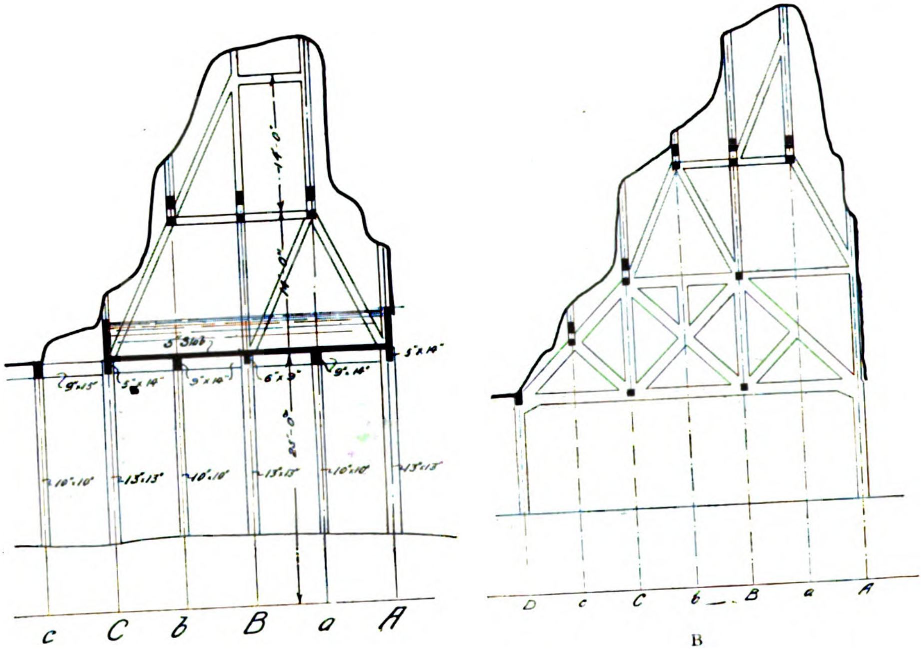
The dens, which are formed under the upper terrace, are each about 12 ft. by 6 ft. and 6 ft. 6 in. high, and these have floors, walls, and roof of reinforced concrete 5 in. and 6 in. in thickness, with reinforcement in both directions and surfaces. The wall adjacent to the enclosure is continued up above the floor of the upper terrace for a height of nearly 7 ft., to prevent visitors being seen from the lower terrace levels, as this would detract from the natural appearance as far as the animals are concerned; but small windows are being formed in the wall to allow a view into the enclosures from the upper terrace.



Photograph by Ernest Milner] [*London*, S.W.

Fig. 7. Under side of Bear Pond, showing Suspension.
REINFORCED CONCRETE PANORAMA, ZOOLOGICAL GARDENS.

The construction of the goat hills required a great deal of careful consideration and setting out, as they are very irregular, and yet of necessity they need to be rigid, on account of the height. Two typical sections are illustrated in



A

B

Fig. 8. Bracing under Goat Hills.

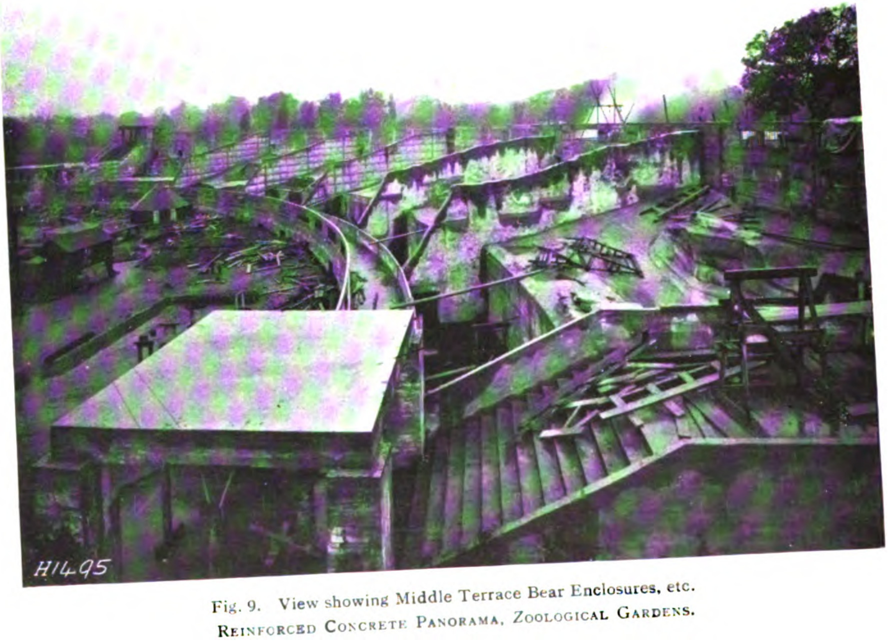


Fig. 9. View showing Middle Terrace Bear Enclosures, etc.

REINFORCED CONCRETE PANORAMA, ZOOLOGICAL GARDENS.

Fig. 8, these being taken through the second and third hills. The lower part of the construction consists of several rows of columns, about 17 ft. high above the ground level, and the actual hill does not commence until this level is reached. These columns are 10 in. or 13 in. square, and they are reinforced with four vertical bars ½ in. diameter, with links at 6 in. pitch. The underside of the base is at a level of 2 ft. below the ground, and consists of a slab 2 ft. 9 in. square, having a minimum thickness at the other edges of 9 in., increased to 18 in. at the intersection with the column shaft. The tops of the columns are connected by radial and tangential beams which vary in size from 9 in. by 6 in. to 14 in. by 9 in. according to the position. All the columns and braces above these beams are 9 in. by 9 in. and reinforced with four ½-in. bars and links

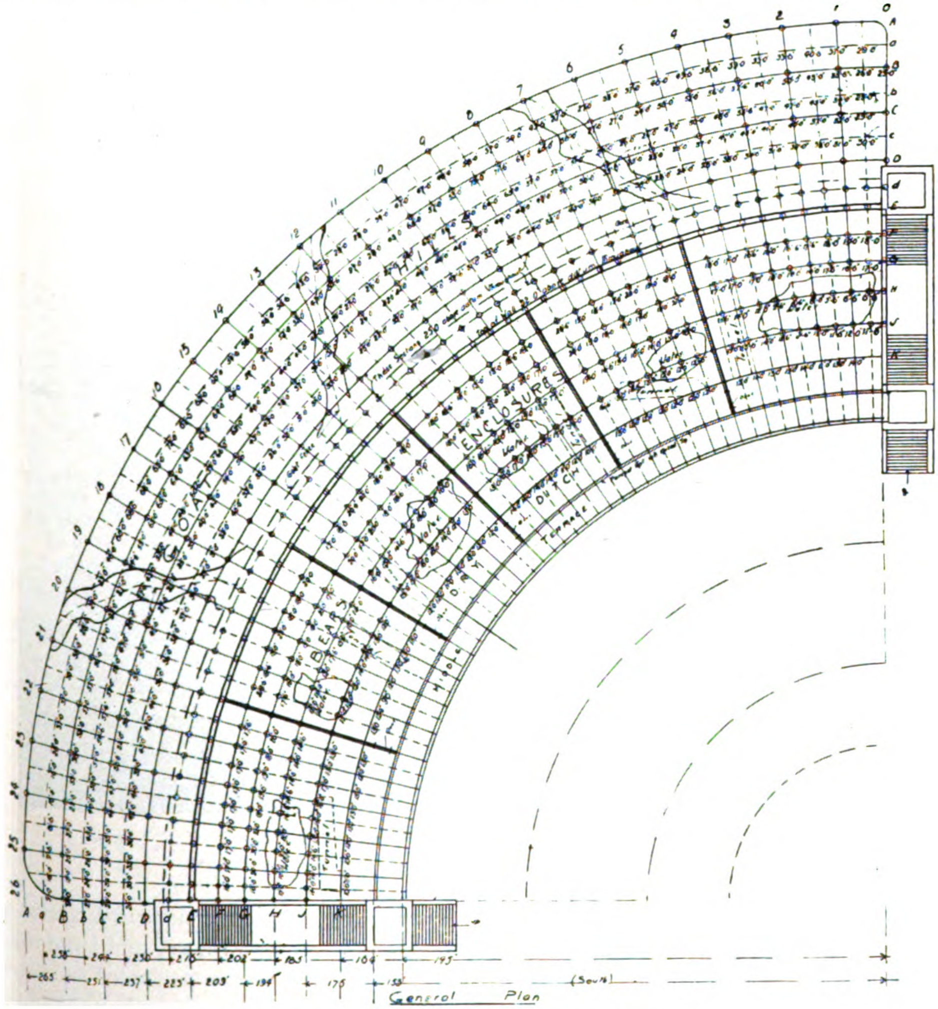


Fig. 10. General Plan, showing Arrangement of Columns.
Reinforced Concrete Panorama, Zoological Gardens.

spaced at 12-in. centres. The space under the second hill is partially occupied by a large water tank, shown in *Fig.* 8 on the Diagram A, and this tank supplies the ponds in the bear enclosures. It has a mean width of 30 ft., a length of 32 ft., and is 3 ft. 9 in. deep. The bottom and sides are formed with 5-in. reinforced slabs carried by 14 in. by 9 in. main beams, and 9 in. by 6 in. secondary beams, reinforced generally with four ½-in. bars and $\frac{3}{16}$-in. stirrups. The water from the goat hills is collected and taken to this tank, and the overflow is connected to the main supplying the bear ponds, and the latter can be quickly filled, as the tank is constantly full and a supply always available.

The trussing under the third goat hill, marked B in *Fig.* 8, is somewhat different owing to the intermediate columns being omitted with the object of providing a large hall that can be utilised for many purposes, such as lectures on natural history. Two rows of columns only are employed here, and large reinforced concrete trusses having a span of about 42 ft. are constructed as shown in the section. The thickness of the covering slabs varies somewhat according to the position and loading, but the minimum thickness employed is 3 ins. These slabs were formed by ramming the concrete between two layers of wire netting spaced at the distance apart required for thickness, and the ramming of the concrete caused the netting to bulge and produce an irregular surface, and in addition the fine stuff projected through the holes in the netting. The outer surface was treated with a stiff broom, which caused this projecting stuff to spread and cover the netting entirely, and at the same time a suitable surface

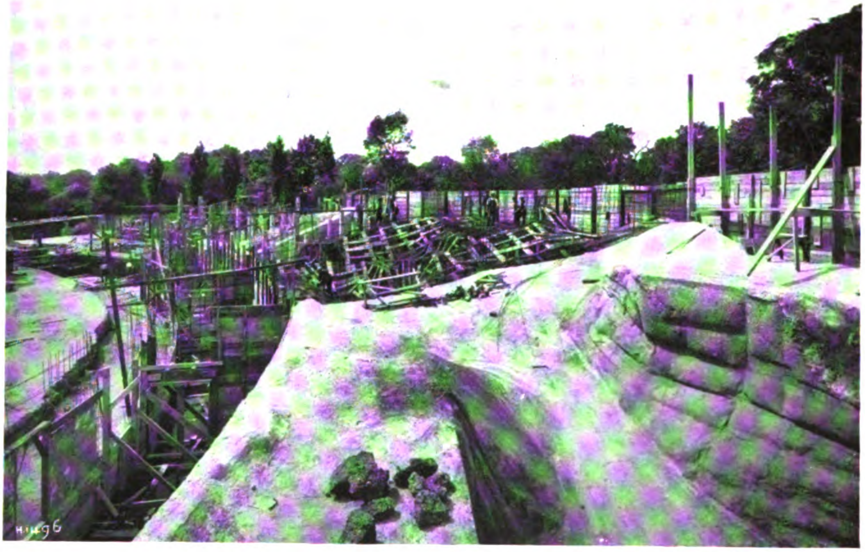


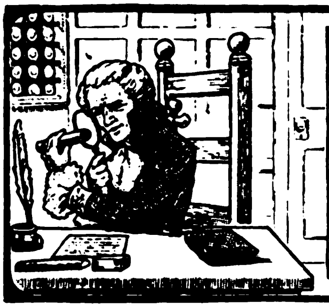
Fig. 11. Bear Enclosure during Construction.
REINFORCED CONCRETE PANORAMA, ZOOLOGICAL GARDENS.

finish was obtained. The outer surface is therefore sufficiently rough for the goats to climb, and is reinforced by the netting, which is quite additional to the main reinforcement of the slab itself. The whole appearance is very pleasing, and when seasoned and toned down by the weather should present a very natural effect. A ladder is provided in the interior of the hill to allow the keeper to pass up to the top with food, which is passed through a feeding hole at this point, thus inducing the goats to climb well up into the view of the visitors. A safety railing is fixed on the outside of the hill some way down from the top to prevent unfortunate goats from being butted or falling to the ground below. The staircases leading from the lower to the upper terraces are 14 ft. wide, and they are reinforced with bars in the soffits in both directions, and an intermediate transverse beam is also provided in the centre of each flight. The landings are formed with 5-in. slabs also reinforced in the soffits in both directions, and the bars in the flights are carried well into the landing concrete.

The whole of the concrete is being mixed by machinery, and the proportions generally adopted are 1 : 2 : 4.

The Consulting Engineer for the scheme is Mr. Alexander Drew, of 64, Victoria Street, and the contractors are Messrs. D. G. Somerville & Co., Ltd., of 120, Victoria Street, Westminster.

It will be readily understood that the nature of the work necessitated a great deal of ingenuity in the execution, and many points had to be left to the foreman on the site, especially with regard to the irregular surfaces of the bear enclosures and goat hills. It was quite impossible to indicate the complete contour of all these irregular surfaces on the drawings, and scale models were therefore made for the guidance of the contractors, who are executing the work in an excellent manner. It would not have been feasible to construct this panorama in any material other than reinforced concrete, and for this reason the work probably illustrates its adaptability to any form of construction more clearly than any other example in the country.



ALIGNMENT CHARTS FOR CONSTRUCTIONAL FORMULÆ.

By EWART S. ANDREWS, B.Sc.Eng., M.C.I.

The following article should call for the attention and consideration of Engineers and others interested in this subject of Alignment Charts.—ED.

Within recent years an interesting method of plotting charts, known as the Alignment Chart method, has been extended very successfully to use for engineering formulæ. As far as the writer is aware, the first use of these diagrams in a British publication is to be found in the Structural Steel Section Book recently issued by Messrs. Redpath, Brown and Co., Ltd. The method is, I believe, of French origin, and has been developed very largely by Professor Peddle, of the Rose Polytechnic Institute, U.S.A., in articles in the *American Machinist* and in a book entitled "The Construction of Graphical Charts" (Hill Publishing Co.), in which this and other interesting methods of graphical representation are set out.

In the present article it is proposed to explain the nature of these charts and to show how they can be drawn, illustrating the method by constructing charts for suitable well-known constructional formulæ.

Underlying principle of alignment charts.

The construction is based upon an unusual method of plotting co-ordinates. The methods commonly considered in co-ordinate geometry are the Cartesian or rectangular co-ordinate method and the polar co-ordinate method.

The rectangular method is shown in *Fig.* 1, which represents a linear function $ax + by = c$.

It will be remembered that in this method of plotting values x and y are taken in directions at right angles to each other and corresponding to simultaneous values of x and y we get a point P.

In the method forming the basis of the alignment chart two parallel lines, XX, YY (*Fig.* 2), are drawn at a convenient distance d apart, and

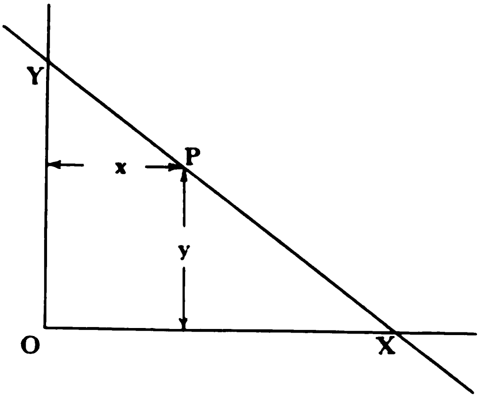


Fig. 1.

starting from the base line XY we set up XP equal to x and YQ_1 equal to y. Instead of having a point to represent simultaneous values of x and y we now have the straight line PQ_1. Now supposing that x and y are connected together by a linear relation of the form $ax+by=c$ (1), and supposing that new values of x and y are found and plotted to give points P_2, Q_2, then P_2Q_2 cuts P_1Q_1 in S, and if equation (1) holds, S will be a fixed point called the *support*, so that by putting one straight edge through any particular value of x, and also through S, the edge will intersect the line YY at the point which will enable us to read off at once the corresponding value of y. Before proceeding to the proof of this fact it must be pointed out that an alteration of S upon the line AS, called the "support line," will correspond to an alteration of the constant c in the formula, and by obtaining a suitable scale for lengths upon the line AS we can treat c as a variable quantity, and so use the chart for solving an equation in which there are three variables.

Proof of construction :—

Draw SR and PT horizontal.

Then the $\triangle$ S, SQ_1R and PST are similar.

$$\therefore \frac{ST}{Q_1R}=\frac{PT}{SR}$$

$$i.e.\ \frac{z-x}{y-z}=\frac{XA}{AY}=\frac{e}{f}$$

We will assume that S is a fixed point—*i.e.*, $z=$constant, and $\frac{XA}{AY}=$constant.

$$\therefore \frac{z-x}{y-z}=\frac{e}{f}$$

or $f(z-x)=e(y-z)$,

i.e., $fx+ey=ez+fz$,

i.e., $fx+ey=z(e+f)$. (2)

Now z, e and f are constant, so that equation (2) represents a linear relation.

It is shown, therefore, that by drawing from values of x on the line XX through the support, the resulting value of y on the line YY follows the linear relation of equation (2).

Going back, therefore, to the original equation (1) we have

$$ax+by=c.$$

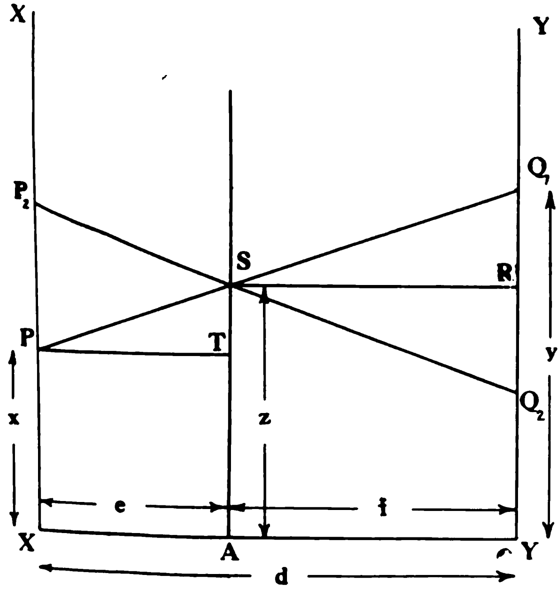


Fig. 2

For convenience we will write this as

$$x+\frac{by}{a}=\frac{c}{a} \qquad (3)$$

and we will write (2) as

$$x+\frac{ey}{f}=\frac{z(e+f)}{f}=z\left(\frac{e}{f}+1\right) \quad (4)$$

From (3) and (4) we get

$$\frac{e}{f}=\frac{b}{a} \quad (5)$$

and

$$\frac{c}{a}=z\left(\frac{e}{f}=1\right)=z\left(\frac{b}{a}+1\right)$$

i.e. $\frac{c}{a}=\frac{z\,(a+b)}{a}$

or $z=\frac{c}{a+b}$ (6)

It will be noted that

$(e+f)=d$

∴ re-writing (5) as

$$\frac{e}{e+f}=\frac{b}{a+b} \quad (7)$$

we see that

$$\left.\begin{aligned} e&=\left(\frac{b}{a+b}\right)d \\ f&=\left(\frac{a}{a+b}\right)d \end{aligned}\right\} \quad (8)$$

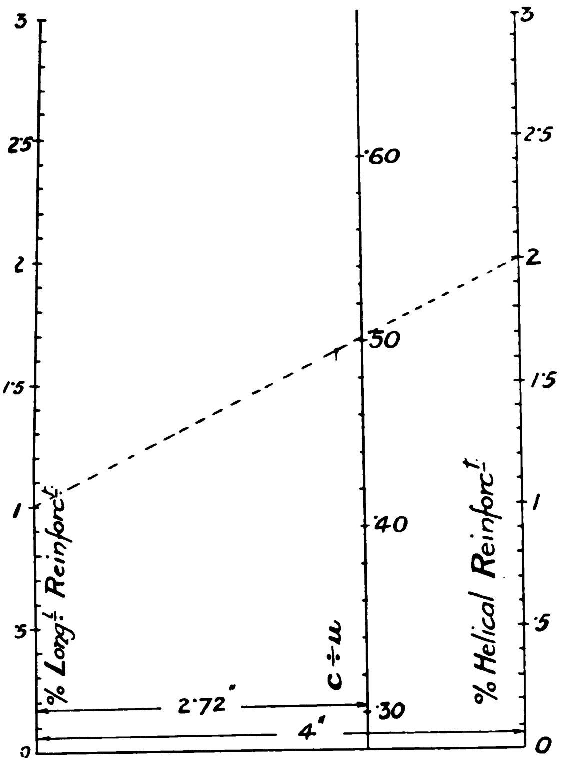


Fig. 3. CHART FOR FRENCH REINFORCED CONCRETE FORMULA.

We note also that the values of e and f are independent of the constant c, whereas z depends on c, so that, as previously stated, by altering the constant we do not alter the support line, but only vary the position of the support upon the line.

SCALES.—Suppose that for the sake of convenience in certain problems the x and y lengths are plotted to different scales, say, 1 in. $=S_x$ units for x and 1 in. $=S_y$ units for y.

Then we shall have

$$e=\frac{bS_y}{aS_x+bS_y}d \quad (9)$$

and the scale for the support values will be

$$S_z=1\ \text{inch}=aS_x+bS_y \quad (10)$$

Example of Reinforced Concrete Column Formula.

It is now proposed to illustrate the use of these diagrams or alignment charts by drawing one for the formula for helically reinforced concrete columns specified by the French Government, viz. :—

$$c=\cdot 28\,u\left(1+\frac{15\ V_L}{V}+\frac{32\ V_H}{V}\right) \quad (11)$$

In this formula

c = Permissive compressive stress per sq. in. on the column.
u = Ultimate compressive stress on the concrete.
V = Volume of core.
V_H = Volume of helical reinforcement.
V_L = Volume of longitudinal reinforcement.

The reinforcements are usually spoken of as percentages.

Let $p_L = \%$ longitudinal reinforcement $= \frac{100\,V_L}{V}$

„ $p_H = \%$ helical reinforcement $= \frac{100\,V_H}{V}$

Therefore, re-writing our formula, we have

$$\frac{c}{u} = \cdot 28(1 + \cdot 15p_L + \cdot 32p_H)$$
$$= \cdot 28 + \cdot 042p_L + \cdot 090p_H \qquad (12)$$

Starting at a convenient point set out p_L, the per cent. longitudinal reinforcement, to a suitable scale, say, 1 in. = ·5 = S_x, taking a range of values from 0 to 3 per cent. Then set out at a convenient distance $d = 4$ in. away from this line a scale of helical reinforcements—the same scale 1 in. = ·5 = S_y will be suitable.

In our formula $a = \cdot 042$, $b = \cdot 090$.

Therefore by equation (9)

$$e = \frac{\cdot 090 \times \cdot 5}{\cdot 042 \times \cdot 5 + \cdot 090 \times \cdot 5} \times 5 = 2\cdot 72 \text{ inches.}$$

The scale for $\frac{c}{u}$ is given by equation (10)

$$S_z = \cdot 042 \times \cdot 5 + \cdot 090 \times \cdot 5 = \cdot 066 = 1 \text{ inch.}$$

The constant ·28 shows us that when p_L and p_H are each equal to O, $\frac{c}{u} = \cdot 28$, so we know that the line joining the points O,O intersects the support line at ·28.

Since 1 in. = ·066, ·02 will be given by $\frac{\cdot 02}{\cdot 066} = \cdot 303$ in., so setting up ·303 in. from the bottom we get the ·30 mark for $\frac{c}{u}$, and so get the other divisions as indicated. The divisions are not continued beyond ·60 because the regulations state that the compressive strength shall not exceed ·6 of the ultimate strength. Suppose, for instance, that we have a column with 1 per cent. longitudinal reinforcement and 2 per cent. helical reinforcement, we place a straight edge across the corresponding points on the chart, as shown in dotted lines, reading $\frac{c}{u} = \cdot 501$.

If, therefore, u = 2,000 lb. per sq. in., c will be about 1,000 lb. per sq. in.

Extension to Product Formulæ.

The alignment chart may be applied to product formulæ (which are much more common in practice than those which we have considered up to the present) by taking logarithms, thus bringing the formula into linear form.

Take, for instance, $P^n\,Q^m = R^p \times A$, where A is a constant.
Taking logs. we get :—

$$n \log. P + m \log. Q = p \log. R + \log. A. \qquad (13)$$

An alignment chart can then be drawn for this formula in the manner previously explained, although greater care is required for the plotting.

Example of Formula for Steel Beams.

This case can be illustrated by the well-known formula for steel beams

$$M = fZ, \qquad (14)$$

where M = safe bending moment on the beam in inch tons,
f = safe stress in tons per sq. in.,
Z = section modulus of beam in inch units.

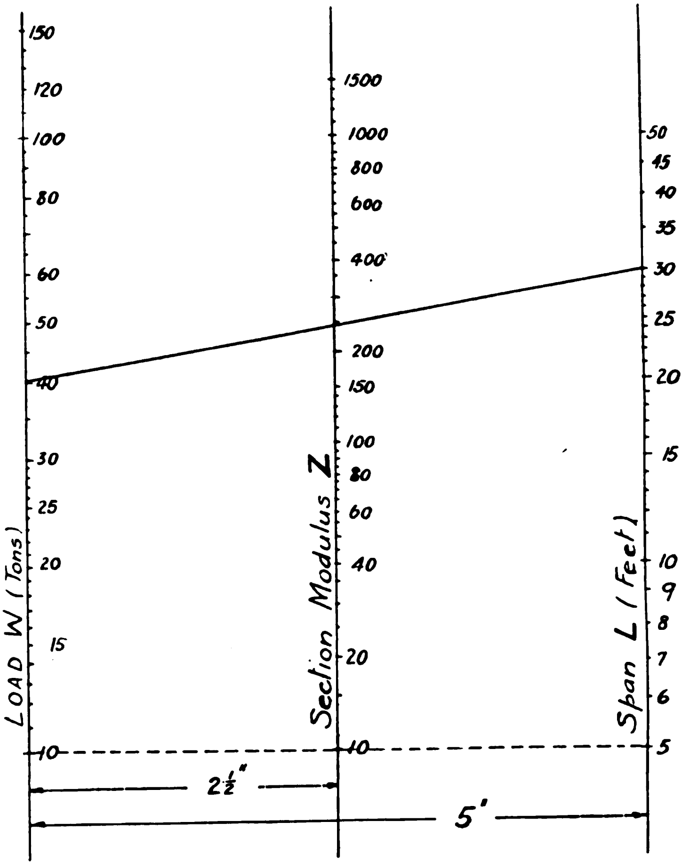


Fig. 4. Chart for Steel Beams.

For a uniformly distributed load upon a span of L feet, $M = \frac{W \times (12L)}{8}$, and f is usually taken as 7·5.

Our formula, therefore, comes to

$$\frac{12WL}{8} = 7\cdot5Z$$

or $WL = 5Z$. (15)

$\therefore \log. W + \log. L = \log. 5 + \log. Z$.

We will take a range of W from 10—150 tons.

$\therefore \log. W$ varies from 1 to 2·176.

A suitable scale for this will be 1 in. = $S_x = \frac{1}{5}$, and *Fig.* 4 was originally drawn to this scale. With a little practice these logarithmic scales can be drawn with comparative ease. Take, for instance, a convenient point near the bottom of the right-hand line of *Fig.* 4 and mark it 10. Now log. 150 = log. 10 + log. 15 = log. 10 + 1·176, so take a distance equal to 5 × 1·176 = 5·88 in. above the 10 line and mark it 150. To find intermediate points we proceed in exactly the same manner. For 30, for instance, we have log. 30 = log. 10 + log.

3 = log. 10 + ·477. ·477 to our scale is ·477 × 5 = 2·39 in. nearly, so mark a point 2·39 in. above the 10 mark and call it 30; the same distance above this point will give 90.

On the opposite side at a convenient distance apart—say, 5 in.—we draw the L line and we will take as a suitable range of values of L 5 ft. to 50 ft. Log. 50 − log. 5 = log. 10 = 1. The same scale, 1 in. $= S_y = \frac{1}{5}$, will be convenient for this, so mark a convenient point 5 and set up 5 in. above it and mark that point 50, obtaining intermediate points in the manner previously described.

To draw the Z scale we first find the position of the support line as follows:—

By equation (9) $e = \dfrac{b\,S_y}{a\,S_x + b\,S_y}\cdot d.$

In the present case $a = b = 1$, $d = 5$, $S_x = S_y = \frac{1}{5}$.

$$\therefore e = \frac{\frac{1}{5}}{\frac{1}{5}+\frac{1}{5}}\cdot 5 = 2{\cdot}5.$$

We therefore draw in the Z line as shown. Next its scale is determined by equation (10), viz.:—

$$S_z = a\,S_x + b\,S_y$$
$$= \tfrac{1}{5} + \tfrac{1}{5} = \tfrac{2}{5}$$

No record has been kept of the zero points of the W and L scales, and we do not require to know them, because it is seen by putting $W = 10$ and $L = 5$ in equation (15) that $Z = 10$. We therefore join across the points $W = 10$ and $L = 5$ as shown in dotted lines and mark the intersection on the Z line 10.

The Z scale is then divided up as follows:—Take, for instance, $Z = 200$, log. 200 = log. 10 + log. 20 = log. 10 + 1·301; to our scale this is given by $\dfrac{1{\cdot}301 \times 5}{2}$ in. = 3·25 in., so set up 3·25 inches above the 10 point and mark it 200. The chart is then soon completed.

To use it, suppose that we want to find the section modulus necessary for a beam to carry a uniformly distributed load of 40 tons over a span of 30 ft.; place a straight edge across the points 40 and 30 as shown in full lines and read of $Z = 240$. From a table of standard sections a suitable section can be found at once, or if beams of a definite type only are used the sizes can be marked on the Z line at the opposite side.

In actual use of the chart it is not necessary to draw the lines across; it is better not to do so.

Extension to Four Variables.

These charts can be extended for use with four variables in the following manner. We will illustrate the point by a consideration of the same formula for steel beams, but will take the stress as variable. Our formula is:—

$$\frac{W \times 12L}{8} = f\,Z \tag{16}$$

$$\text{i.e., } Z = \frac{1{\cdot}5\,WL}{f} \tag{17}$$

$$\text{i.e., } \log. Z = \log. 1{\cdot}5 + \log. W + \log. L - \log. f. \tag{18}$$

$$\text{Let } v = \log. W + \log. L. \tag{19}$$

The log. 1·5 may be neglected for the present because it has only the effect of shifting the zero for the Z scale. So we may write

$$\log. Z = \log. v - \log. f. \qquad (20)$$

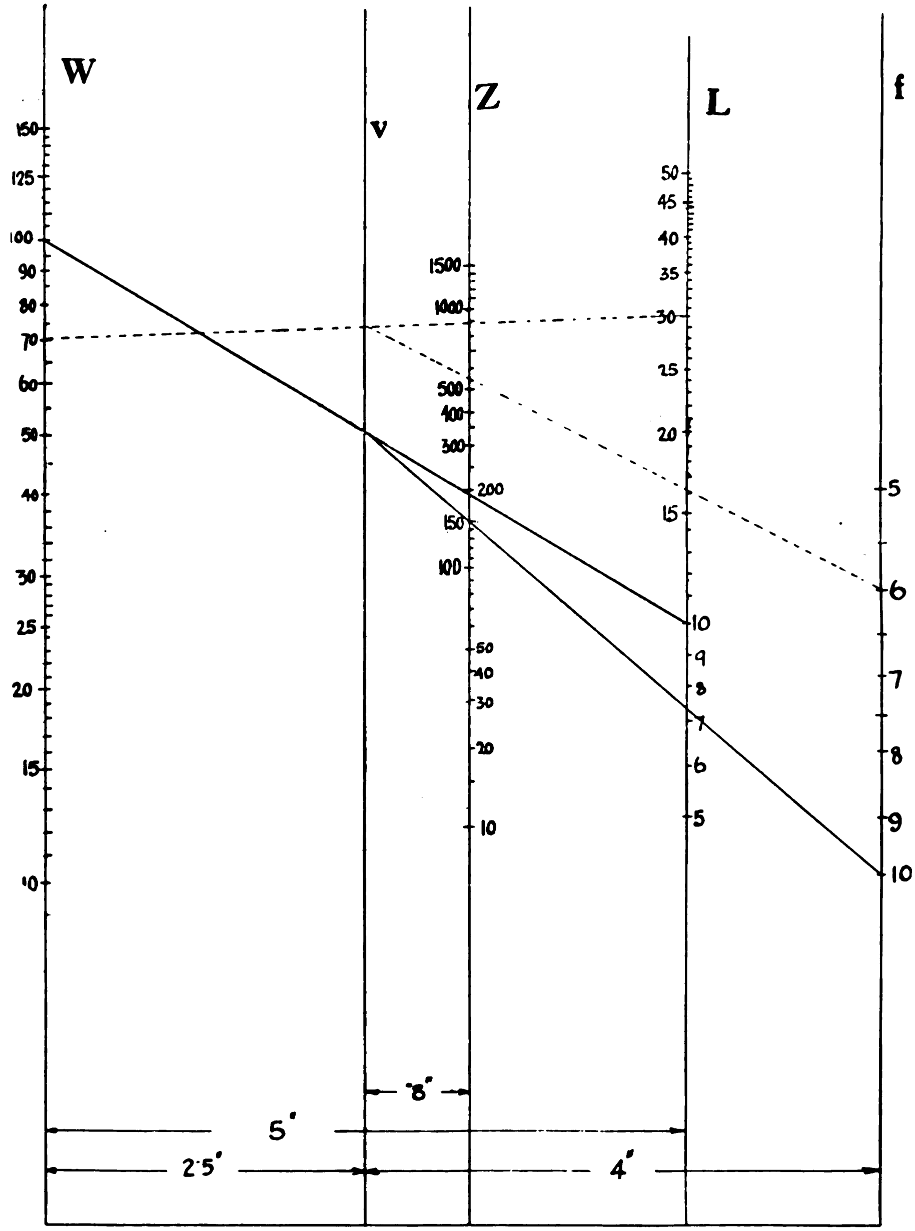


Fig. 5. Chart for Steel Beams with Variable Stress.

Fig. 5 has been drawn to represent this formula, and before describing the manner in which it is drawn it would be well to indicate the manner in which it is used. Suppose that we have a load of 70 tons on a span of 30 ft., the working stress being 6 tons per sq. in. Place a straight edge along the points 70 and 30 on the W and L scales respectively (as shown in dotted lines) and mark the intersection of the v or common support line; join this intersection to the point $f=6$; then its intersection on the Z scale gives the modulus required, viz., 525.

To draw the scales we first decide upon the range of values and take

W from 10 to 150 tons.
L from 5 to 50 ft.
f from 5 to 10 tons per sq. in.

Taking W and L lines at 5 in. apart and plotting each to a scale 1 in. $=S_L=S_W=\cdot 2$ in., the logarithms of the values are plotted conveniently by the method previously explained.

Since in this case $a=b=1$ and $S_x=S_y=\cdot 2$, we have

$$e=5\times\frac{\cdot 2}{\cdot 2+\cdot 2}=2\cdot 5 \text{ in.}$$

Support scale 1 in. $=S_v=\cdot 2+\cdot 2=\cdot 4$.

We do not need, however, to plot values on the support, because it is not used for reading from, but we use this result later to obtain the Z scale. Now draw our f line at, say, 4 in. from the common support and choose a suitable scale, say, 1 in. $=S_f=\cdot 1$.

It will be noted in equation (20) that log. f has to be subtracted, so we set values of log. f downwards, as shown, instead of upwards.

The Z support distance from the v line will then be $e_z=\frac{1\times\cdot 1}{\cdot 1+\cdot 4}\cdot 4=\frac{4}{5}=\cdot 8''$

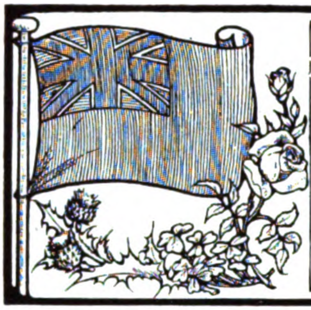
The Z scale is 1 in. $=S_z=1\times\cdot 1+1\times\cdot 4=\cdot 5$.

We have kept no record of our zero points, so that to get a point on the Z scale we take convenient values in the original equation (19)—$W=100$, $L=10$, $f=10$.

$$\therefore Z=\frac{1\cdot 5\times 100\times 10}{10}=150.$$

We therefore join across as shown in full lines and mark the intersection on the Z line 150, obtaining other points on this scale as previously described. To get $Z=50$, for instance, we have $\frac{150}{50}=3$, therefore log. $150=\cdot 477+$ log. 50. Now $\cdot 477$, to a scale 1 in. $=\cdot 5$, is $\cdot 954$ in., so mark this distance down from the point $Z=150$ and mark it 50.

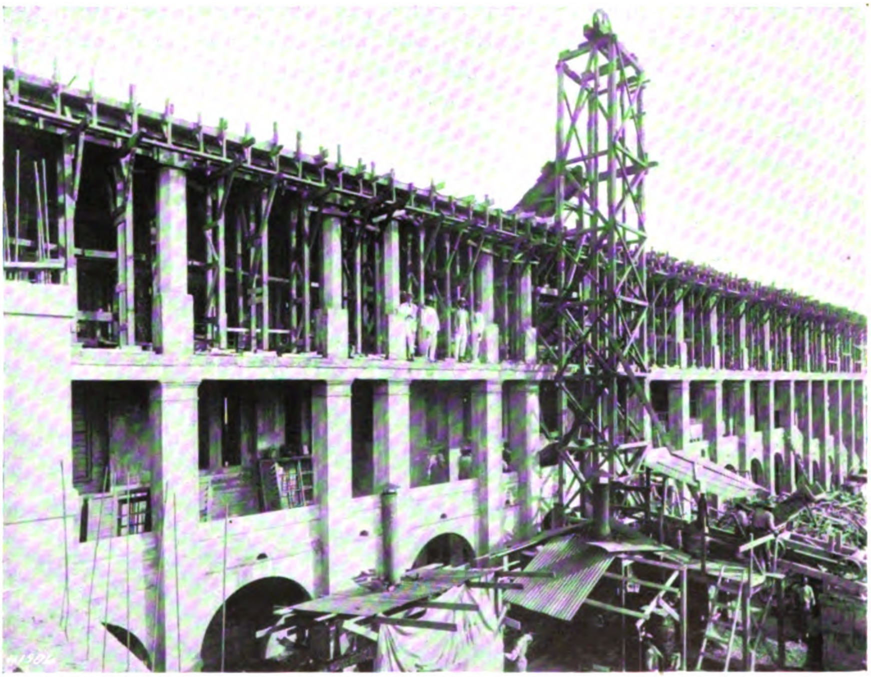
The endeavour of the above article has been to show how to draw and use these alignment charts rather than to give a large number of charts of use to engineers. Most of the formulæ used by designers can be charted in this manner, and such charts are very useful for designing.



REINFORCED CONCRETE IN THE NEW LAW COURTS AT KINGSTON, JAMAICA.

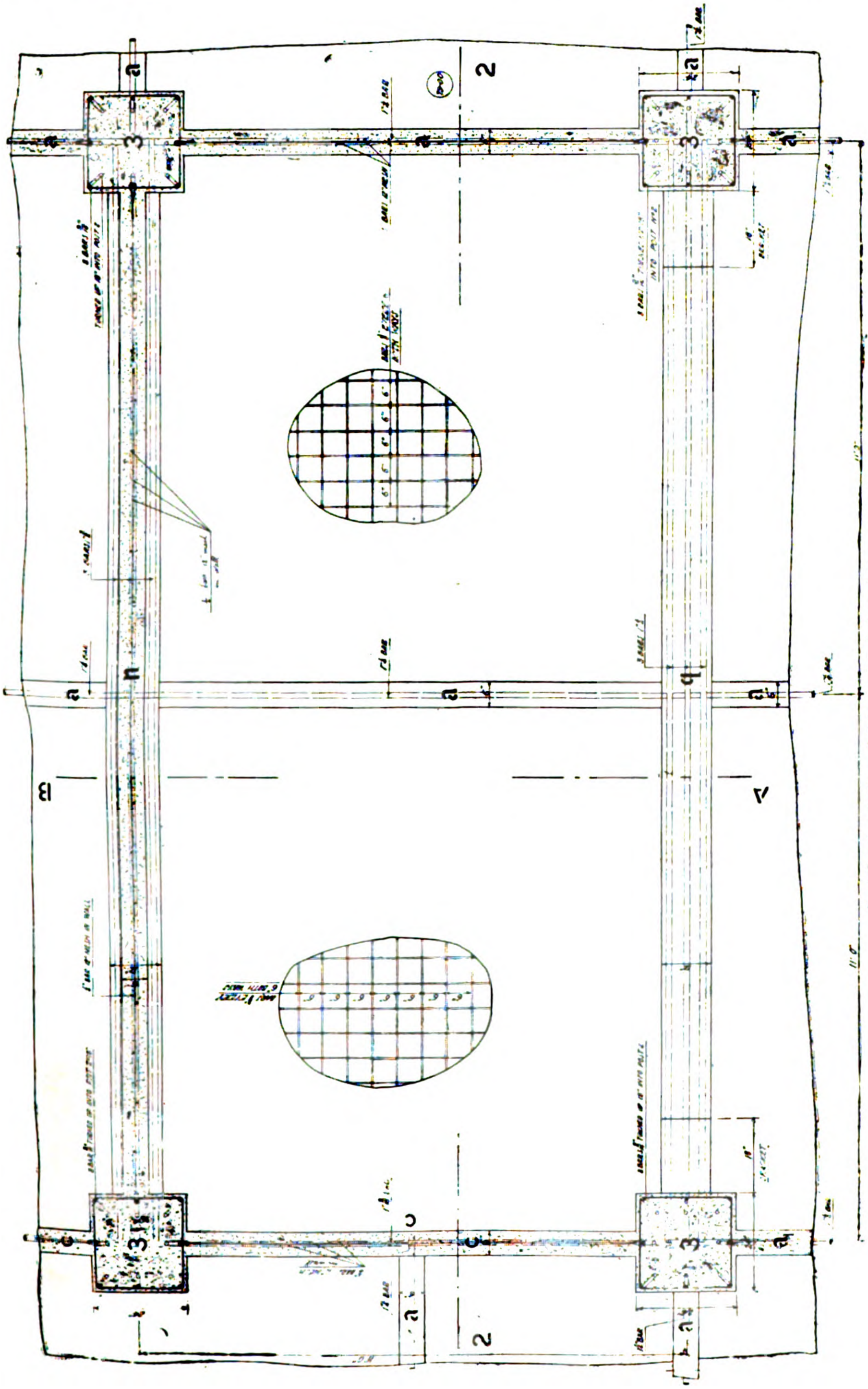
A former article dealing with these buildings was published in our Journal, Vol. VI, p. 85, and the following particulars, with illustrations and drawings showing details of the reinforced concrete construction, may therefore be of particular interest.—ED.

OUR readers will no doubt recollect that we have already published, in one of our previous numbers, a short description of this new building, which was then in course of construction, and which has now been recently completed. The entire structure is in reinforced concrete on the Coignet System.

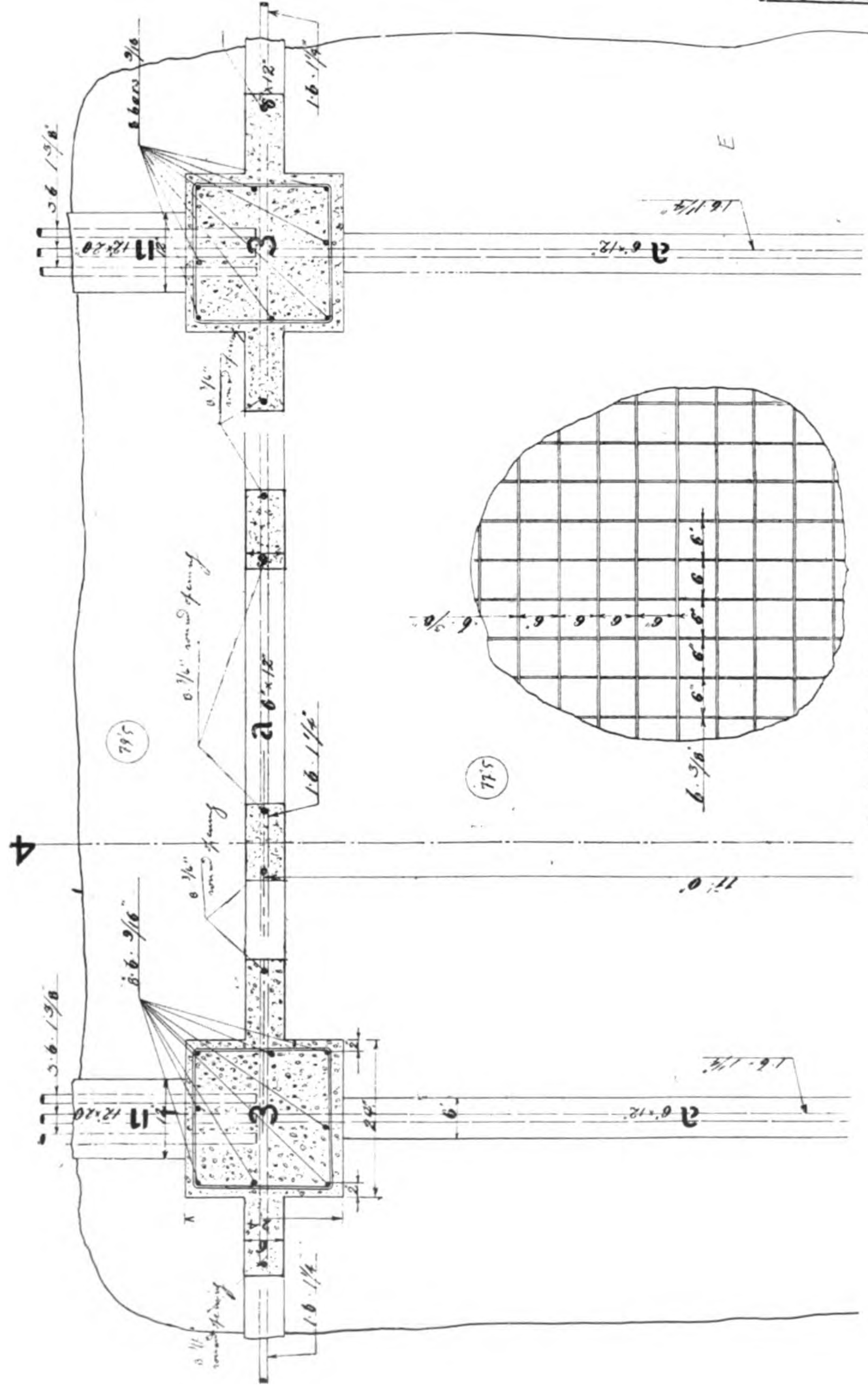


West Front in course of construction.
NEW LAW COURTS AT KINGSTON, JAMAICA.

This building is the third public building erected on this system at Kingston, the architects appointed by the Government being Messrs. Nicholson & Corlette,



Part Sectional Plan of Principal Reinforced Concrete Floor.
New Law Courts at Kingston, Jamaica.

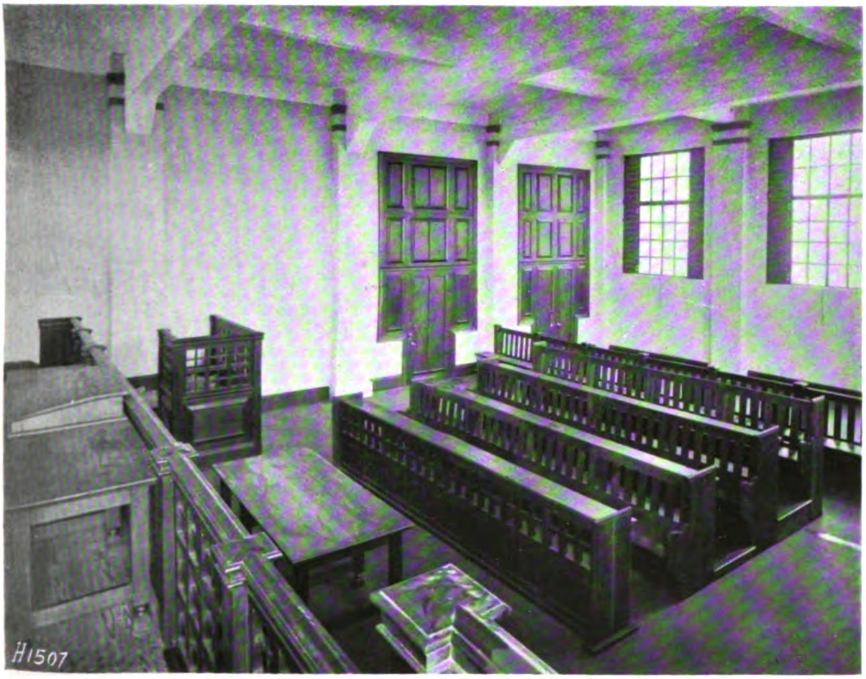


Details of Reinforced Concrete Floor.
New Law Courts at Kingston, Jamaica.

of London. The other buildings were the new King's House, or Residence of the Governor, and the Post Office and Treasury buildings.

All this group of buildings, which has been designed by the architects for the special purpose of offering the greatest possible amount of resistance to earthquake shocks and fire, has been designed on the same architectural lines.

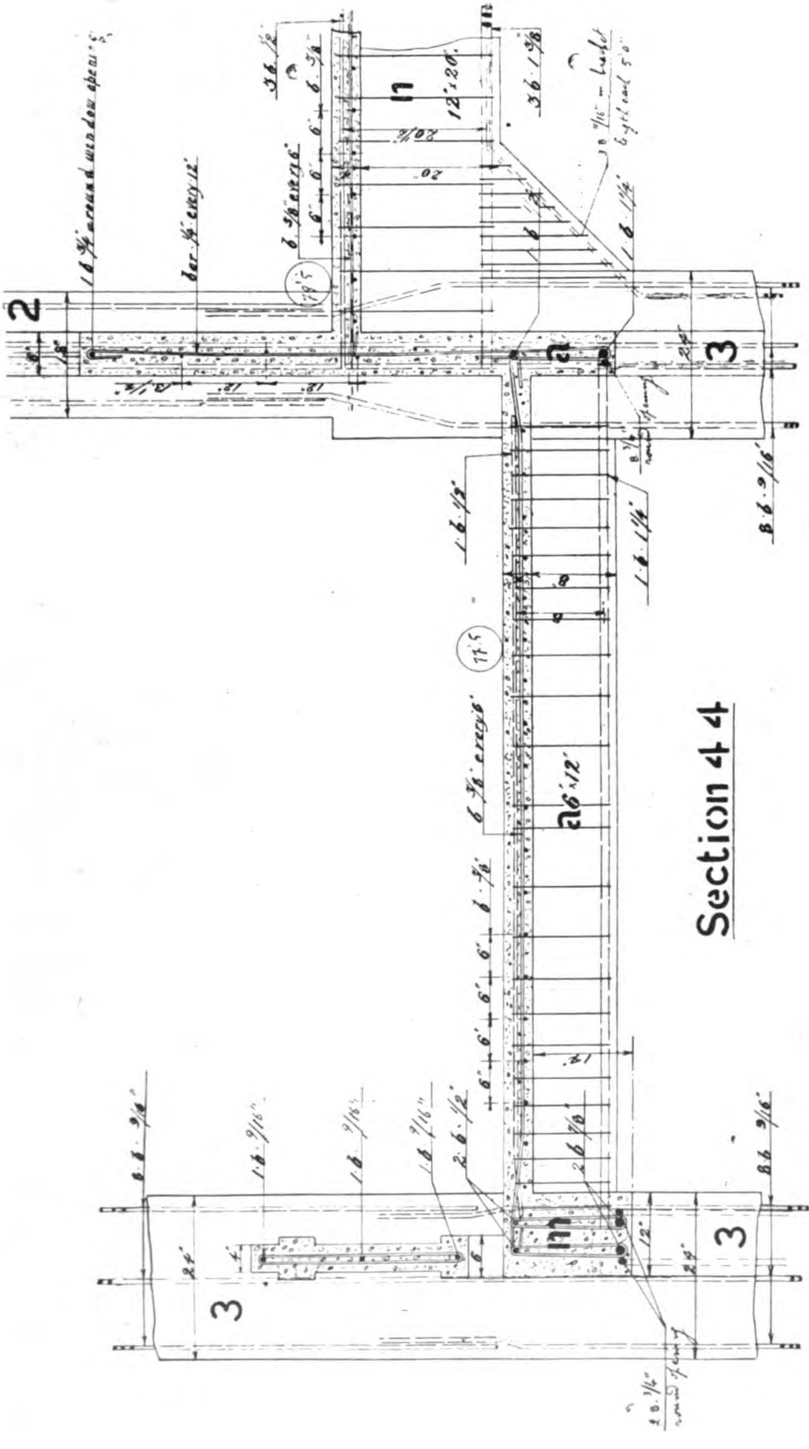
Each building is constructed upon a strong reinforced concrete raft distributing the load uniformly upon the ground, and the entire building is braced together in such a manner that it constitutes a thoroughly monolithic structure, and it has been proved by actual experience that this method of construction is the best suited to resist earthquakes.



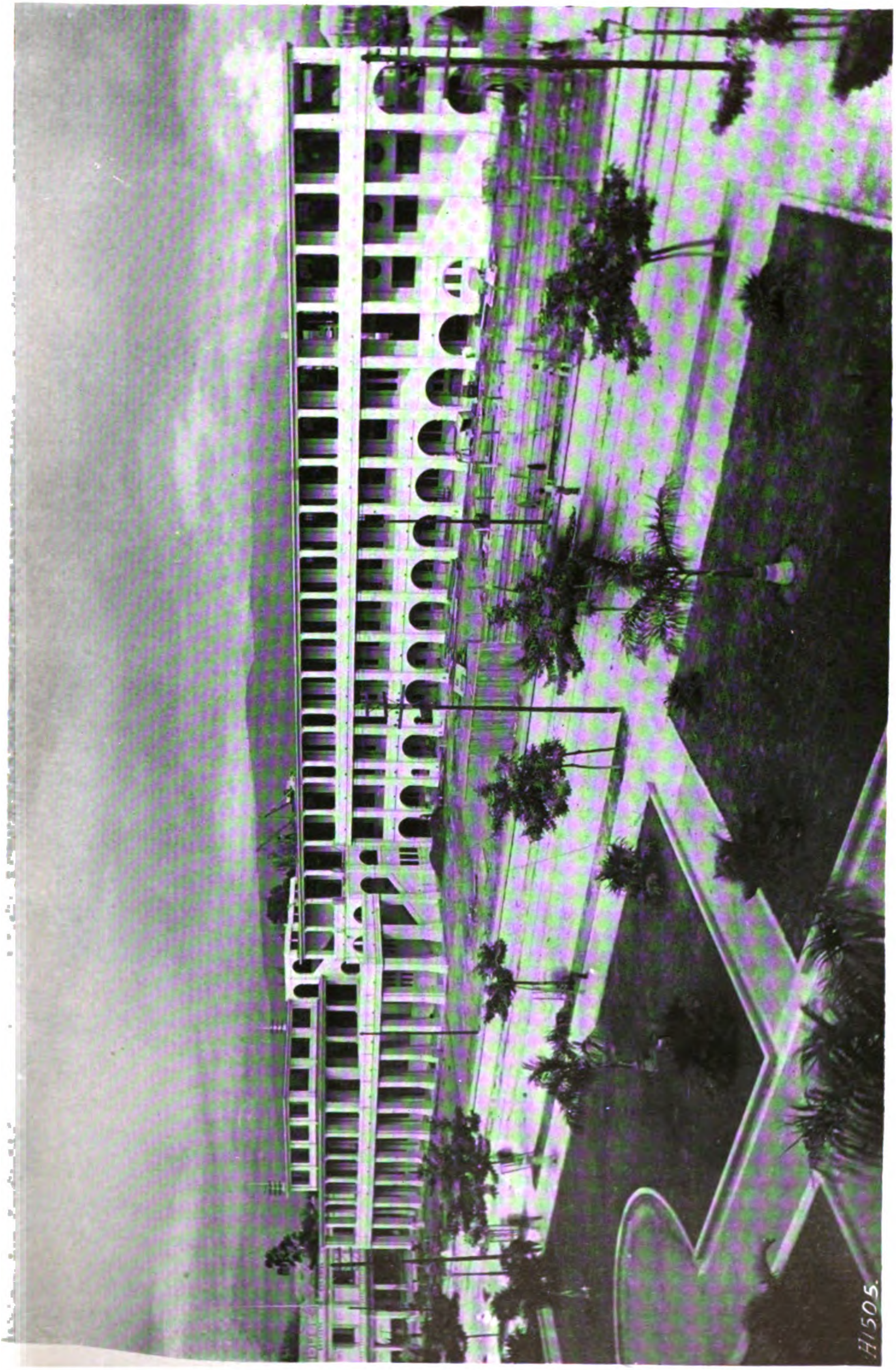
Interior View, Kingston Court.
NEW LAW COURTS AT KINGSTON, JAMAICA.

As shown in the accompanying photographs, this building is surrounded by spacious verandahs in order to prevent, as much as possible, the rays of the sun penetrating into the rooms. All the roofs are flat and are protected from the heat by a layer of gravel several inches in thickness. As shown in the photographs illustrating the interiors of the court-rooms, the ceilings are kept as high as possible to ensure proper ventilation. In fact, every detail of the design has been carefully considered to suit the tropical conditions of the climate. The wooden fittings, such as benches, platforms, and doors, are made of solid mahogany.

The general dimensions of the building are as follows:—A total length



Details of Principal Reinforced Concrete Floor.
New Law Courts at Kingston, Jamaica.



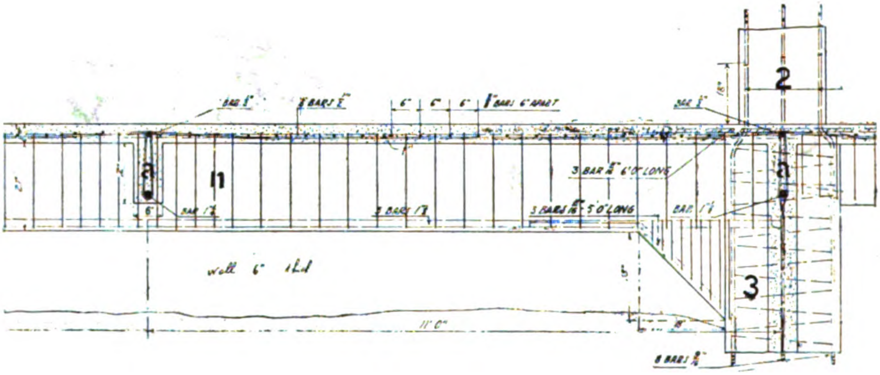
West Front Completed.

NEW LAW COURTS AT KINGSTON, JAMAICA.

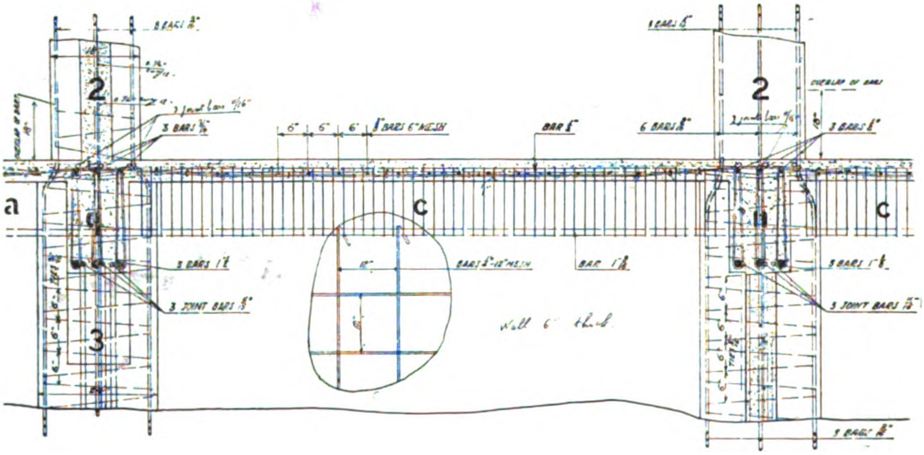
of about 258 ft. and a total width of 92 ft. in the smallest width and 136 ft. in the largest width, the height from the foundations to the roof being approximately 45 ft.

The building is composed of a ground floor, first and second floors, and a flat roof. The stairs are also constructed entirely in reinforced concrete. The total area of each floor measures approximately 22,000 sq. ft.

The plans for the execution of the reinforced concrete were prepared by Messrs. Edmond Coignet, Ltd., of 20, Victoria Street, London, S.W., and the contract for the execution of the work was carried out by Messrs. Mais & Sant, contractors, of Kingston. The work was, of course, entirely executed by native labour under skilled supervision, and this is another proof of the adaptability of reinforced concrete to colonial buildings.



Section of Principal Reinforced Concrete Floor.



Cross Section of Reinforced Concrete Floor.
NEW LAW COURTS AT KINGSTON, JAMAICA.

The reinforced concrete system which was used for this building is composed of a special arrangement of ordinary round bars of mild steel, the columns being formed by four or more upright bars surrounded by spiral hooping of small diameter. The beams are composed of one or more straight bars at the top and bottom, connected together by vertical stirrups of small diameter. These steel frames being prepared in advance on the site, they are simply placed in the moulds ready for concreting.

The floor slabs, usually about 4 in. in thickness, are composed of a meshwork of bars spaced about 4 in. or 5 in. apart. The walls are made in a similar manner and reinforced by means of horizontal and vertical bars forming a meshwork.

Some typical sections are given in this article showing the reinforcement of columns, beams and floors, which clearly show the arrangement of the bars.

Interior View Supreme Court.
New Law Courts at Kingston, Jamaica.

A REINFORCED CONCRETE CHIMNEY.

By JOHN W. RODGER.

The question of the suitability of reinforced concrete for chimney construction has been the subject of considerable debate and also much doubt. Any information, therefore, relating to such structures will be welcomed, as it will add to our store of knowledge on the subject. We, therefore, give below the following particulars of a chimney recently erected in South Wales.—ED.

THE South Wales Portland Cement and Lime Co., Ltd., are erecting a new rotary plant at their cement works, Penarth, near Cardiff, and have built a chimney of a somewhat interesting description for carrying away gases from the kiln.

The chimney is fourteen-sided externally and 220 ft. high above ground, formed in two parts, the outer of concrete blocks and the inner part or lining of bricks. The outer concrete shell and the inner brick lining are entirely unconnected throughout their full height.

All steel concrete work above ground was carried out by Messrs. Monoshaft, Ltd., under their patented methods.

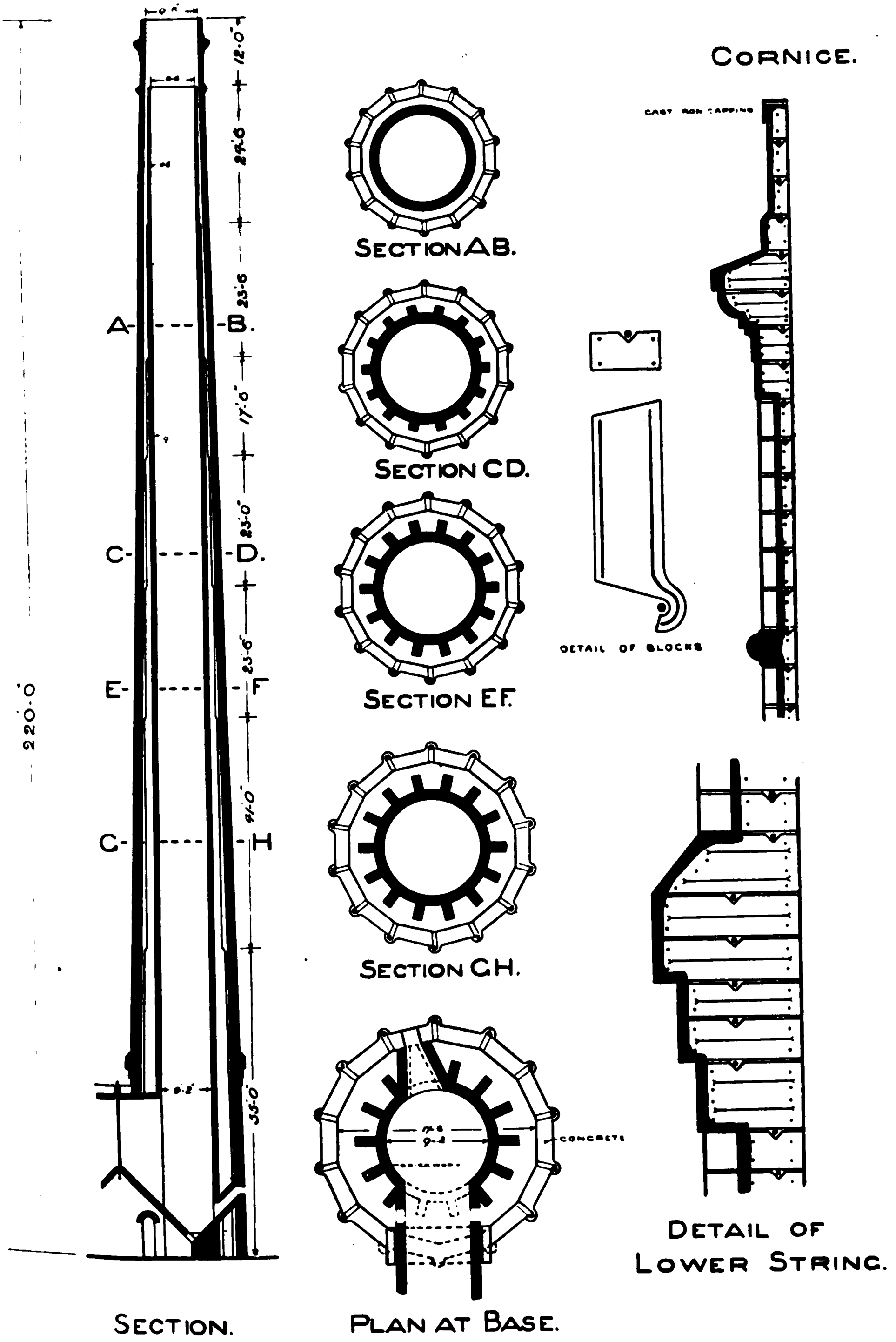
The blocks are composed of concrete in the proportions of 9 cubic ft. of crushed granite to pass a ¾ in. sieve, with all fine and dust removed, 5 cubic ft. of clean coarse sand, and 3 cubic ft. of Portland cement, mixed by hand and moulded in cast-iron moulds of varying sizes and shapes, care being taken that the mixture was a wet plastic and of such a consistency as could be efficiently worked into the moulds to form a dense concrete.

Each block is reinforced with steel rods of varying diameter bedded in the concrete during the process of moulding.

The blocks are set in a mortar of cement and sand 1 : 2 with a steel ring or joint rod the entire circumference of the chimney, bedded in each horizontal joint. Vertical reinforcement is obtained by steel rods fixed in the end joints of the blocks and further protected by concrete neckings moulded as part of the blocks and showing as vertical shafts on the finished structure.

Each vertical rod is carried 6 ft. down into the concrete foundation and there attached to a horizontal steel ring, the full diameter of the chimney at its base. Special reinforcement was used round and over the flue opening and to the moulded cornice and neckings.

The chimney stands on a concrete foundation slab composed of cement concrete 1 : 6.



CORNICE.

SECTION AB.

SECTION CD.

SECTION EF.

SECTION GH.

DETAIL OF LOWER STRING.

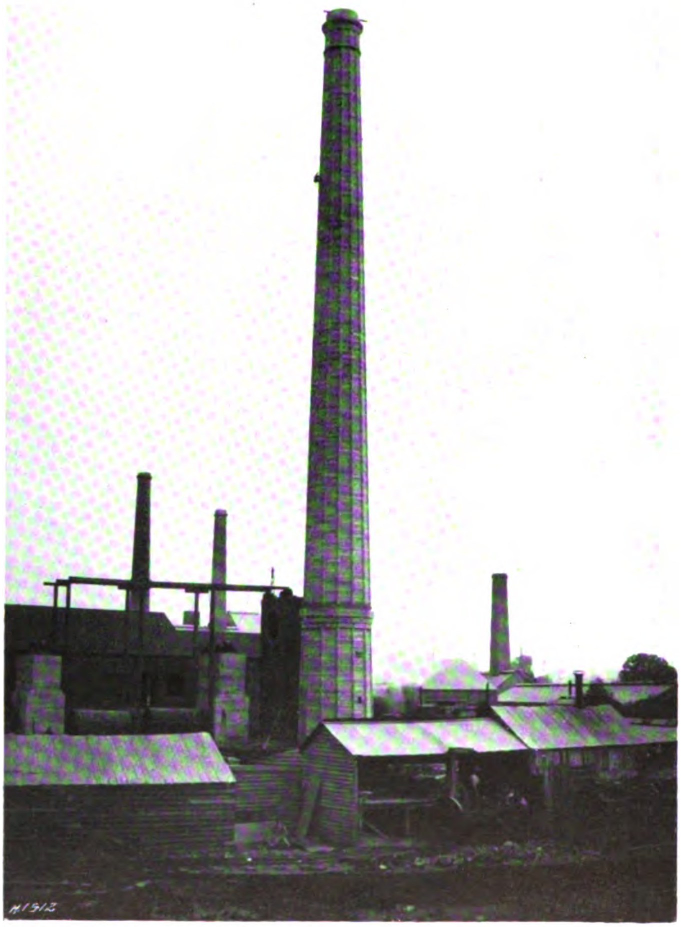
SECTION.

PLAN AT BASE.

REINFORCED CONCRETE CHIMNEY AT PENARTH.

The general dimensions are :—

	ft.	ins.	
Concrete foundation slab	23	6	square.
Height of chimney above ground	220	0	
Outside diameter of chimney at base	20	6	
Outside diameter of chimney at top	10	4	
Thickness of blocks at base	1	6	
Thickness of blocks at top		5	
Weight on bottom course of blocks = 8½ tons per square ft.			
Batter	1 in 43		



View of Completed Structure.
REINFORCED CONCRETE CHIMNEY AT PENARTH.

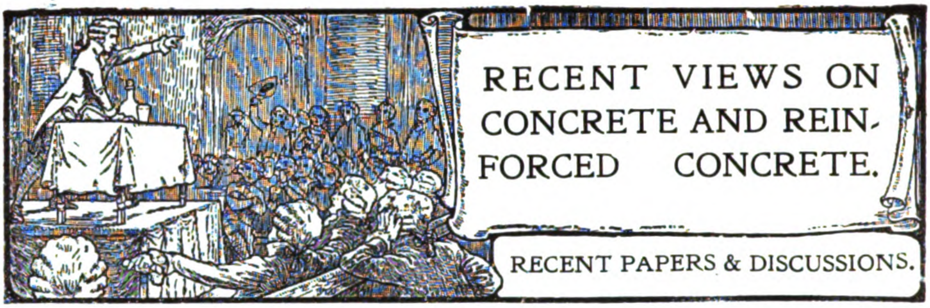
At the outset it was realised that the chimney might at times be subjected to exceptionally high temperatures, and it was deemed advisable to build the brick lining to within 12 ft. of the top with a substantial air space between the concrete and brickwork as a special protection to the concrete.

The brick lining is 9 in. thick to a height of 183 ft. 6 ins. and 4½ ins. thick above that point, strengthened laterally by buttresses projecting into the cavity. No brickwork is allowed to come nearer than 6 ins. to the concrete, as a precaution against damage to the lining by the swaying action of the chimney in a high wind. The estimated maximum deflection is 81 mm. in a gale blowing 80 miles an hour.

The lining is built throughout of hard red Cattybrook bricks, made to correct radius and set in cement and sand mortar 1 : 2 to the level of the bottom of the intake flue, and above that point to the top of the 9-in. work in mortar composed of ½ part Portland cement, 1 part slaked ground blue lias lime, and 2½ parts sand. The 4½-in. brickwork is set in cement and sand mortar 1 : 2.

The total weight of the chimney and concrete foundation is approximately 1,400 tons, equal to 2½ tons per sq. ft. on the subsoil foundation.

The chimney was built under the direction and supervision of the writer, acting as architect for The South Wales Portland Cement and Lime Co., Ltd., associated with Mr. W. J. Cooper, managing director of the company.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

RECENT PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

THE DIFFERENTIAL AND INTEGRAL CALCULI FOR STRUCTURAL ENGINEERS.

By W. A. GREEN, M.A., B.Sc., Eng. (St. Andrews), Assoc.M.Inst.C.E.

The following is an abstract from a Paper read at the Fortieth General Meeting of the Institute.

AFTER a few introductory remarks, the author went on to say that we cannot avoid definitions, and my first will be that of a "function of a quantity," which is shortly defined as an expression involving that quantity. Thus we may say that the maximum bending moment in a cantilever is a function of the length and also of the loading, and generally when the relationship between quantities can be expressed by an algebraic equation one quantity is said to be a function of the others. The symbol for "function" is left to the personal predilection of the writer, and may, when applied to the quantity x, be $f(x)$, $\phi(x)$, $\psi(x)$, etc.

Starting with two related quantities, which we may symbolize as x and y, we may express their relationship by an equation $y=f(x)$ or $x=\phi(y)$.

As every engineer knows, we can, by taking in the equation $y=f(x)$ different values for x, find corresponding values for y, and tabulate them—*e.g.*, the safe load on stanchions for different heights.

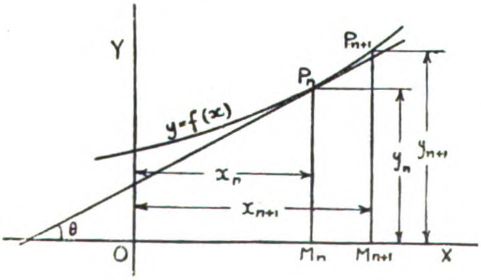


FIG. 1.

A much more illuminating and often easier way of recording these tabulated results is to plot them in a curve, letting vertical distances from a fixed line equal one quantity to some convenient scale, and horizontal distances to another fixed line at right angles to the first, the other quantity. The two fixed lines are known as the axes, and their point of intersection the origin of co-ordinates. There are, of course, many other ways of representing graphically the relationship between the two quantities, but perhaps none more obvious and simple.

The corresponding values of x and y are known as co-ordinates, and $y=f(x)$ is termed the equation of the curve so plotted.

In the diagram (*Fig.* 1) where OX and OY are our fixed axes, let $OM_n=x_n$, $P_nM_n=y_n$, x_n and y_n being the co-ordinates of P_n, a point on the curve whose equation is $y=f(x)$.

Then from our previous definition we know that $y_n = f(x_n)$.

Similarly let the co-ordinates of P_{n+1} be x_{n+1} and y_{n+1}, connected by the equation $y_{n+1} = f(x_{n+1})$.

As a point moves along the curve from P_n to P_{n+1} in the example shown, its distance from both axes increases and it has moved a distance $y_{n+1} - y_n$ up, and a distance $x_{n+1} - x_n$ to the right.

Provided this distance is small enough, its path will not differ greatly from a straight line whose slope is the same as the line touching the curve at P_n and called, for short, the tangent.

The slope of this line can be measured by the ratio of its vertical travel to its horizontal travel, for a less obvious reason called the tangent of the angle the tangent line makes with the axis OX, which angle, for reference, we will call θ.

A short way of expressing the increase in the length of the y co-ordinate as the point moves from P_n to P_{n+1} is δy, and of the x co-ordinate, δx where δ is not a multiplier but a sign of a small increase in the quantity it comes before—δ, by our standard notation, standing for difference.

When δx and δy are very small their ratio is termed the first differential coefficient of y with regard to x, and its value is obviously the tangent of θ.

If $y = ax$ and x_n and y_n are the co-ordinates of a point on the curve, and $(x_n + \delta x)$ $(y_n + \delta y)$ the co-ordinates of a point near it, we know that $y_n = ax_n$ and $(y_n + \delta y) = a(x_n + \delta y)$.

$$\therefore \frac{\delta y}{\delta x} = \frac{y_n + \delta y - y_n}{\delta x} = \frac{a(x_n + \delta x) - ax_n}{\delta x} = a\frac{\delta x}{\delta x} = a,$$

i.e., the direction of the curve is constant; or, in other words, the curve is a straight line which perhaps it did not need the differential calculus to demonstrate.

Taking another equation $y = ax^2$. As before—

$$\frac{\delta y}{\delta x} = \frac{y + \delta y - y}{\delta x} = \frac{a(x_n + \delta x)^2 - a(x_n)^2}{\delta x}$$
$$= \frac{a(x_n^2 + 2x_n\delta x + \delta x^2) - ax_n^2}{\delta x}$$
$$= \frac{2ax_n\delta x}{\delta x} + a\delta x = 2ax_n + a\delta x,$$

When δx is very small its value compared with $2ax_n$ may be neglected, and $\frac{\delta y}{\delta x} = 2ax_n$, *i.e.*, the tangent to the curve at the point whose x co-ordinate is x_n is $2ax_n$.

We may express it more generally by saying that for every value of x the first differential coefficient of ax^2 is $2ax$.

This statement is equivalent to saying that the slope of the curve varies directly as the x co-ordinate.

As everybody knows, this particular curve is our constant friend the parabola with its axis vertical (see *Fig.* 2) and as the slope of the tangent is $2ax$, which equals $\frac{ax^2}{x/2}$, the tangent to the curve must halve the x co-ordinate.

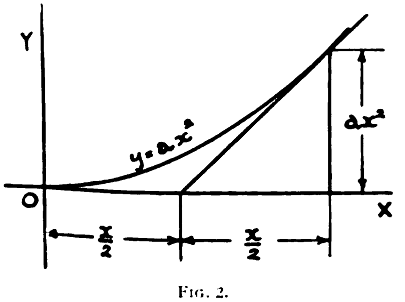


FIG. 2.

Taking as our third example $y = ax^3$, and treating it for the general point whose co-ordinates are x and y—

$$\frac{\delta y}{\delta x} = \frac{y + \delta y - y}{\delta x} = \frac{a(x + \delta x)^3 - ax^3}{\delta x}$$
$$= \frac{a(x^3 + 3x^2\delta x + 3x\delta x^2 + \delta x^3) - ax^3}{\delta x}$$
$$= \frac{3ax^2\delta x}{\delta x} + \frac{\delta x^2}{\delta x}(3ax + a\delta x)$$

$= 3ax^2 + \delta x$, multiplied by an expression of no further interest to us,

$= 3ax^2$ when dx is infinitely small.

Summarizing.—The first differential coefficient
of $ax = a$
of $ax^2 = 2ax$
of $ax^3 = 3ax^2$
and generally of $ax^n = nax^{n-1}$

true for all values of n positive and negative, including $n=0$ where $x^\circ=1$, $y=a$ and $\frac{\delta y}{\delta x}=0$, which is another way of saying that a line drawn at a constant distance from another line makes no angle with it.

The process of finding the first differential coefficient is known as differentiation, and the symbol for the operation is often written $\frac{d}{dx}$, $\frac{dy}{dx}$ being the value of $\frac{\delta y}{\delta x}$ when both δy and δx are very small.

The values of the first differential coefficient can themselves be plotted to form another curve, and the process of differentiating continued *ad lib.*, the first differential co-efficient of the first differential co-efficient of the original quantity being termed, for short, the second differential co-efficient, and written $\frac{d^2y}{dx^2}$ which indicates that the operation $\frac{d}{dx}$ has been twice repeated.

Similarly, $\frac{d^n}{dx^n}$ need have no terrors for a reader if he is not expected himself to repeat the operation n times.

Perhaps one of the most valuable uses of the differential calculus is the location of maximum and minimum values of a continuously varying quantity.

On each side of a maximum or minimum there are two equal values, and at the maximum, as in water-level at high tide, there is no change in one quantity as the other varies; in other words, the first differential coefficient is zero.

Reverting to the small increment δx, let us, instead of examining its relation with the small quantity δy, discuss it as a multiplier of y.

δx and y being both represented by lines, their product $y\delta x$ is obviously an area, *viz.*, that of the rectangle with base δx and height y.

In *Fig.* 3, if the line M_aM_b, the projection on OX of the portion of the curve $y=f(x)$ between the points P_a and P_b, is divided into a number of small lengths, δx, the area of the figure, $P_aM_aM_bP_b$, is greater than the sum of the areas of the rectangles of area $y\delta x$ by an amount equalling the sum of the small triangular figures each of area $\frac{1}{2}\delta x \times \delta y$, when δx is small enough to make the portion of the curve of which it is a projection, a straight line.

We may write this equation symbolically:—

$$\text{Area } P_aM_aM_bP_b = \sum_{x=a}^{x=b} y\delta x + \tfrac{1}{2}\sum_{x=a}^{x=b} \delta y\delta x$$

where Σ—the Greek S—stands for the sum of all such quantities at $y\delta x$ and $\delta y\delta x$ which follow it, $x=a$ and $x=b$ indicating the limits between which the summation is made.

When δy is infinitely small, each of the terms $y\delta x$ is infinitely small, but as there will be an infinite number of them the sum will be a finite quantity.

The product, however, of two infinitely small quantities will be infinitely small compared with either of them, so that even if an infinite number of them are taken the sum will be infinitely small.

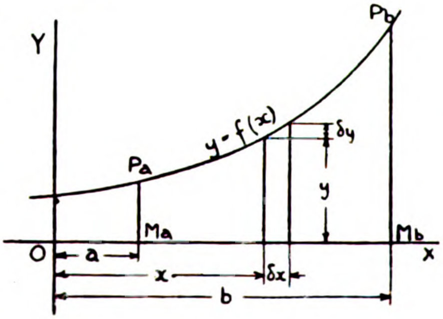


FIG. 3.

The last term of our equation will therefore vanish, and the area may be expressed as:—

$$\sum_{x=a}^{x=b} y\delta x \text{ or } \int_a^b f(x)dx,$$

where an old English f is used for the summation sign, and an English d is substituted for the Greek δ.

This summation is termed integration.

There are, however, difficulties in the way of plotting curves and measuring areas, and a further investigation is necessary.

The shaded area in the diagram (*Fig.* 4) increases as x increases.

Let the increment of x be δx and the corresponding increment of the area be δA.

Then when δx is very small $\delta A = y\delta x$

$$\text{or } \frac{\delta A}{\delta x} = y, \text{ i.e. } \frac{dA}{dx} = y,$$

or the first differential coefficient of $A = y$;

$$\text{but } A = \int_0^x y\delta x \text{ the}$$

integral of y with regard to x.

i.e. if A is the integral of y with regard to x,

y is the differential of A with regard to x,

so that integration and differentiation are inverse operations.

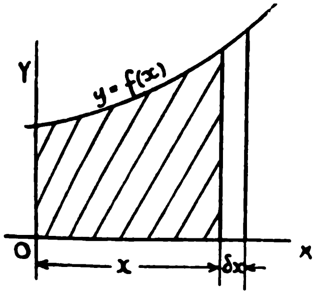


FIG. 4.

In differentiating $f(x)$ with regard to x we find the relation between δx and δy at a point whose co-ordinates are x and y. In integrating $f(x)\delta x$ by finding an expression whose first differential coefficient is $f(x)$ we find an area of the figure enclosed between the curve, the axis OX, the axis OY, and the vertical line through the point xy.

If we wish to integrate between two limits, *e.g.* from $x=a$ to $x=b$ as in the previous illustration—we can subtract the integral from $x=0$ to $x=a$ from the integral from $x=0$ to $x=b$.

We may tabulate our integrals as we tabulated our differentials—

$$\text{As } \frac{d}{dx}\, ax = a \quad \therefore \quad \int adx = ax$$

$$\text{as } \frac{d}{dx}\, ax^2 = 2ax \quad \therefore \quad \int 2axdx = ax^2 \text{ or } \int axdx = \frac{ax^2}{2}$$

$$\text{as } \frac{d}{dx}\, ax^3 = 3ax^2 \quad \therefore \quad \int 3ax^2dx = ax^3 \text{ or } \int ax^2dx = \frac{ax^3}{3}$$

and generally—

$$\text{as } \frac{d}{dx}\, ax^n = nax^{n-1} \quad \therefore \quad \int ax^{n-1}x = d\,\frac{ax^n}{n}$$

The above results satisfy our condition that the integral of a function is another function whose differential is the original function, but to make the statement complete we must add a constant to each, the value of which can be found later and may be zero.

This constant will satisfy our condition as—

$$\frac{d}{dx} \text{ constant} = 0 \text{ and } \therefore \int 0dx = \text{constant}.$$

Just as we could repeat our differentiating operation to find the first, second, third, etc., differentials, so we may repeat the reverse operations to find the first, second, third, etc., integrals so that the sign $\int\int$ is really not so terrible as it appears—

$$e.g.\ \int 0dx = C_1$$

$$\iint 0dx^2 = \int C_1 dx = C_1x + C_2$$

$$\iiint 0dx^3 = \iint C_1 dx^2 = \int (C_1x + C)dx = \frac{C_1x^2}{2} + C_2x + C_3, \text{ etc.,}$$

the truth of which statement can be verified by differentiating the last expression three times and arriving at zero as our final result.

It is unnecessary here to evolve from first principles the equation $f = \frac{Bn}{I}$ where the letters have the significance set forth in the last word in standard notation—

f = intensity of flexural stress at extreme fibre
n = distance of neutral axis from extreme fibre
B = bending moment
I = inertia moment.

It may not, however, be out of place to examine a small element of length δx of a deflected beam a distance x from some arbitrary origin whose neutral axis has been deflected a distance y from some arbitrary base line through the origin (*Fig.* 5).

In the length δx let the inclination with our base line vary from the angle θ to the angle $(\theta + \delta\theta)$, where θ is measured as the ratio of the circular arc it subtends to the radius of the arc.

When an angle is small the difference between this ratio and the tangent of the angle is negligible, so that $\delta\theta$ is the ratio of the contraction of the length δx at the top of the beam under the stress f to the neutral axis distance n. A stress E (the modulus of elasticity) would make δx contract an amount δx if something else did not happen first, so that f would make it contract $\frac{f\delta x}{E}$, and the angle $\delta\theta$ may be expressed as $\frac{f\delta x}{En}$.

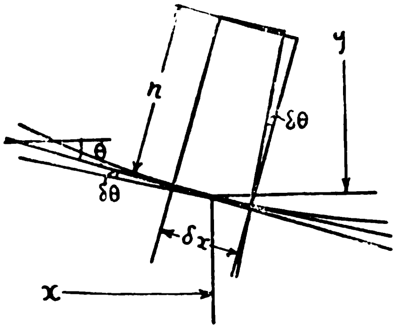


FIG. 5.

If, as is usually the case in structural engineering, θ itself is small, its value is $\frac{dy}{dx}$ so that—

$$\frac{\delta\theta}{\delta x} = \frac{d}{dx}\frac{dy}{dx} = \frac{d^2y}{dx^2},$$

but $\frac{d\theta}{dx}$ also equals $\frac{f}{En}$,

$$\therefore \frac{d^2y}{dx^2} = \frac{f}{En} = \frac{Bn}{I} \times \frac{I}{En} = \frac{E}{BI}.$$

In the equation $\frac{d^2y}{dx^2} = \frac{M}{EI}$

we see on integrating that $\frac{dy}{dx} = \int \frac{M}{EI} dx + C_1$,

i.e. the slope of the curve at any point x from the origin can be measured by the area of the bending moment diagram, the value of the constant C_1 depending on circumstances.

Integrating again we obtain the deflection curve of the neutral axis as—

$$y = \iint \frac{M}{EI} dx^2 + C_1x + C_2.$$

Deflection, slope, bending moment, shear, and loading, may be expressed as a series, in terms of any one of them.

Using bending moment as our basis—

$EI \times$ Deflection $\quad EIy=\int\int B\,dx^2+C_1x+C_2$

$EI \times$ Inclination $\quad EI\frac{dy}{dx}=\int B\,dx+C_1$

Bending moment $EI\frac{d^2y}{dx^2}=B$

Shear $\quad =EI\frac{d^3y}{dx^3}=\frac{dB}{dx}$

Loading $\quad EI\frac{d^4y}{dx^2}=\frac{d^2B}{dx^2}$

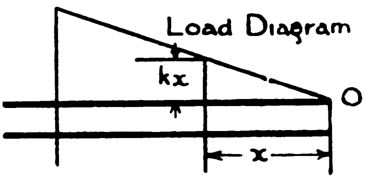


FIG. 6.

for such part of it as is a function of x.

From the above series it will be seen that deflection bears the same relation to bending moment that bending moment does to loading, so to draw a deflection curve one has simply to draw a bending moment diagram for the original bending moment diagram considered as a load diagram.

Another problem presenting difficulties to many engineers is that of internal shear which, with the aid of the calculi, we will attempt to investigate, making the usual assumptions regarding a plane section before bending remaining plane in bending.

Consider a small length dx of the beam cut by two sections normal to the neutral axis—at distances x and $x+\delta x$ from the origin.

Take a section parallel to the neutral axis at a distance a from it.

At x from the origin the extreme bending stress $=\frac{Bn}{I}$;

at $x+\delta x$ from the origin the extreme bending stress $=\frac{(B+\delta B)n}{I}$

where B and $(B+\delta B)$ are the bending moments x and $x+\delta x$ from the origin.

The total horizontal shear on the horizontal section $w^a \times \delta x$ a distance a from the neutral axis equals the difference between the thrust to the right on the part of the vertical section above a, x from the origin, and the thrust to the left on the part of the vertical section above a, $x+\delta x$ from the origin.

This thrust difference may be expressed—

$$\int_a^n w_z f\,\delta z \backsim \int_a^n w_z(f+\delta f)\,\delta z,$$

where w_z is the width of the cross-section z from the neutral axis and f and $f+\delta f$ are the horizontal stresses there x and $x+\delta x$ from the origin.

Then as $\frac{f}{z}=\frac{B}{I}$ and $\frac{f+\delta f}{z}=\frac{B+\delta B}{I}$ the total change in horizontal thrust—

$$=\int_a^n w\,\frac{B}{I}z\,\delta z \backsim \int_a^n w\,\frac{B+\delta B}{I}\,z\,\delta z$$

$$=\int_a^n \frac{w\,\delta B}{I}z\,\delta z=\frac{\delta B}{I}\int_a^n wz\,dz$$

$=\frac{\delta B}{I}\times$ (Area moment about the neutral axis of that part of the vertical cross-section above the horizontal section a from the neutral axis).

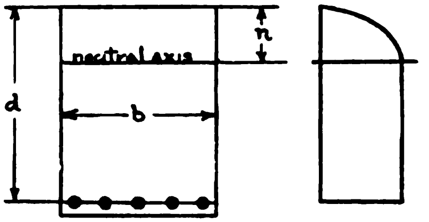
This shear or change in horizontal pressure in the distance δx is on a horizontal area $w_a \times \delta x$, so that the intensity $=\frac{\delta B}{w_a\,\delta x\,I}$ (Area moment of that part, etc.), *i.e.*, shear intensity $=\frac{S}{wI}\times$ (Area moment, etc.), as S the vertical shear $=\frac{dB}{dx}$.

Consider a reinforced concrete beam (see *Fig.* 7) assuming no tension in the concrete—

$$I=\int_0^n zbz\delta z+m\times\text{steel area}\times(d-n)^2$$

$$=\frac{bn^3}{3}+m\times\text{steel area}\times(d-n)^2,$$

the letters having the standard significance—



Cross Section. Shear Intensity.

FIG. 7.

$$\therefore\ \frac{bn^2}{2}=m\times\text{steel area}\times(d-n)$$

$$\therefore I=\frac{bn^3}{3}+\frac{bn^2}{2}(d-n)$$

$$=\frac{bn^2}{2}\left(d-\frac{n}{3}\right)$$

and shear intensity, a maximum at the neutral axis—

$$=\frac{S\times\frac{bn^2}{2}}{b\times\frac{bn^2}{2}\times\left(d-\frac{n}{3}\right)}=\frac{S}{b\left(d-\frac{n}{3}\right)}$$

As the stress in the steel × distance to centre of compression $\left(d-\frac{n}{3}\right)$ equals B, the change in stress per length δx—

$$=\frac{dB}{dx}\times\frac{1}{d-\frac{n}{3}}=\frac{S}{d-\frac{n}{3}}$$

and the shear intensity per unit area $=\dfrac{S}{b\left(d-\frac{n}{3}\right)}$ the same as the concrete shear intensity at the neutral axis, so that the theoretical internal shear is constant below the neutral axis and decreases to zero in a parabolic curve above it.

THE WESLEYAN METHODIST HALL, WESTMINSTER.

By H. V. LANCHESTER, F.R.I.B.A.

The following is an extract of a Paper recently read before the Royal Institute of British Architects. In an earlier issue of this Journal the Wesleyan Hall was fully described as far as the reinforced concrete construction was concerned (see Vol. V., p 721). Our extract has been taken from the Journal of the R.I.B.A., Vol. XXI., No. 2.

In his opening remarks, the author stated that there were a number of problems in the design of this building, the solutions of which present a certain degree of novelty and may be of interest to architects.

After making reference to the competition instituted to procure designs, the difficulty of planning and arrangement are dealt with.

The author set out the accommodation the hall was to contain; he also described the difficulties to be overcome in the construction of the main staircase. Briefly, the principal requirements of the building were:—Large hall, seating 2,500. Small hall, seating 600. Library of the same size (these two to be thrown together on occasions). Conference hall. A room of the same size (now occupied by the London City and Midland Bank). Tea room to seat 1,000. Four committee rooms. A block of offices.

Leaving the minor details of planning, he passed on to the methods of construction employed. Reinforced work has been extensively used in the interior, for the reason that it is more homogeneous than any of the combinations of steel rollings with concrete and other materials. The architects' choice fell on the Kahn system as providing a bar that once in position was visibly adjusted to take up the strains provided for before filling-in commenced. Of course, there are other systems that achieve this aim, but not the slightest ground could be found to regret the selection. Indeed, the only points where slight cracks have shown themselves are where, in order to economise depth, steel sections were resorted to. The author thought it desirable to warn some of those present that the published strengths of steel beams are not reliable; though they are well within the limit of safety, greater depth must be allowed where the slightest deflection will disturb the work above them.

In the general framing up of this building the heaviest weight accumulated at the eight angles of the main dome. Starting from the top, we have the outer dome, a relatively light shell, the much heavier concrete inner dome, the concrete and masonry of the pendentives and the arches across the transepts; then the girders carrying the overhanging galleries, a proportion of the walls and floors below this, and, finally, the weight of the piers themselves. With allowances for wind pressure, etc., the weights reaching the foundations at each of these points range from 500 to 600 tons, and as it was, of course, desirable to equalise the weight as much as possible, a steel raft was provided under each pair of piers, which gave a distributed weight of 2 tons to the foot super. Under the whole of the remainder of the building was a reinforced concrete raft of varying thickness, and the weight on this generally was about 1½ tons per foot super. The eight main piers were formed of steel sections, at the angles of a 3-ft. square, tied together with steel lattice-work, and entirely encased and filled with cement concrete. The architects themselves worked out the methods of construction in these, but throughout the rest of the building they were indebted to Mr. de Colleville, then with the Trussed Concrete Steel Company, for checking calculations and supplying details of connections, riveting, etc. The remaining piers were of reinforced work with vertical bars and horizontal lacing. The basement floor is 7 ft. above the bottom of the concrete, which gave the requisite depth for distributing the weight under the heavier piers and for the provision of ventilating and pipe ducts. The large spaces on the basement floor were covered with thin reinforced concrete vaults, carrying a flat floor about 8 ft. above the street, which is the ground floor of the main building. (The floors of other parts are at different levels.) The floors above this are constructed of reinforced concrete, with hollow tiles to reduce weight.

The galleries demand some description. They are mainly supported by deep girders connected to the lattice stanchions; these form the fulcrum from which they cantilever forward, while the back is built into the main walls. The ramps pass over, and the soffits under, these main girders, so that the cantilevering does not entail excessive weight.

Over the galleries are the transept vaults, elliptical in form, and thicknessed into strongly reinforced beams under the vertical walls of the outer dome. From these beams and the pendentives springs the coffered inner dome of reinforced concrete, with two rings of steel plate to resist the outward thrust.

Although the Large Hall is 70 ft. in height, its dome would hardly be visible from outside; and the outer dome, relatively light in construction, rises some 50 ft. higher, exclusive of the lantern above it. As the design based itself on the conception of a square dome with the angles cut off, forming an irregular octagon, necessarily special constructive requirements had to be met. A circular dome is relatively easy to construct, there being no tendency to distortion; but all other forms have an inclination towards the circular, a straight-sided dome tending to bulge horizontally between the angles. The first step was to provide at the base a plate of great horizontal rigidity firmly tied at the angles. As the weakest points were towards the middle of the four long sides, the ribs were treated in this position as principals tied right across; these are in pairs, connected together at the top with a braced ring, which carries the lantern and links up the angle-ribs, which are also braced on similar lines. These ribs and the intermediate ones carry the steel purlins and timber rafters of the dome covering. The lantern is mainly of timber construction, but stiffened by four steel ribs steeply inclined at the four angles, these ribs carrying the finial rod, and torsion is guarded against by a horizontal bracing near the top of the lantern filled in with cement concrete.

The lecturer closed with some remarks regarding the engineering requirements and the architectural treatment.

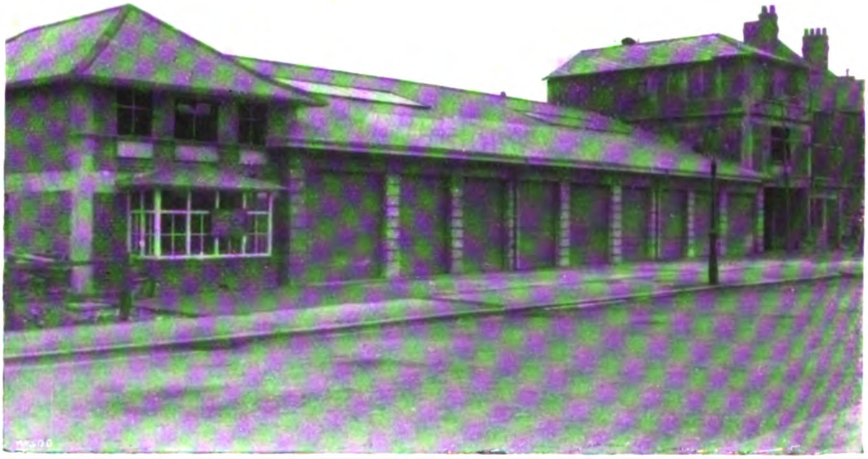
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

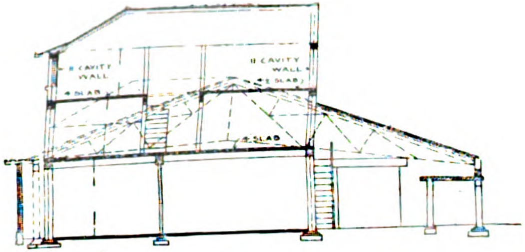
A REINFORCED CONCRETE MOTOR GARAGE, WHITBY.

THE accompanying illustrations show a motor garage recently erected at Whitby. The structure is a concrete-frame building, with 9 in. brick walls around the garage and 11 in. cavity brick walls around the house. The columns and beams to the front of the building are moulded reinforced concrete. As will be seen from the accompanying plans, in addition to the motor garage, the following rooms have been provided, namely, a drivers' room, workshop, woodwork shop, lavatories, and showroom. The house adjoining consists of two floors, comprising sitting-room, entrance hall, store, kitchen, scullery, and four bedrooms and a bathroom. All the floors are of reinforced concrete, whilst the roof is covered with asbestos tiles. Further, the staircases are also built in concrete. The contractors for this building were Messrs. George Greenwood Sons, of New Brunswick Street, Halifax, who carried out the work on the Rigid System of reinforcement, according to drawings supplied by The Rigid Reinforcement and Concrete Engineering Co., Ltd. The architect was Mr. Harold G. Walker, of Whitby. We are indebted to Messrs. Greenwood Sons for our particulars and illustrations.

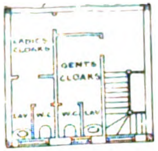


View of Completed Structure.

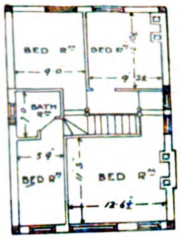
REINFORCED CONCRETE MOTOR GARAGE, WHITBY.



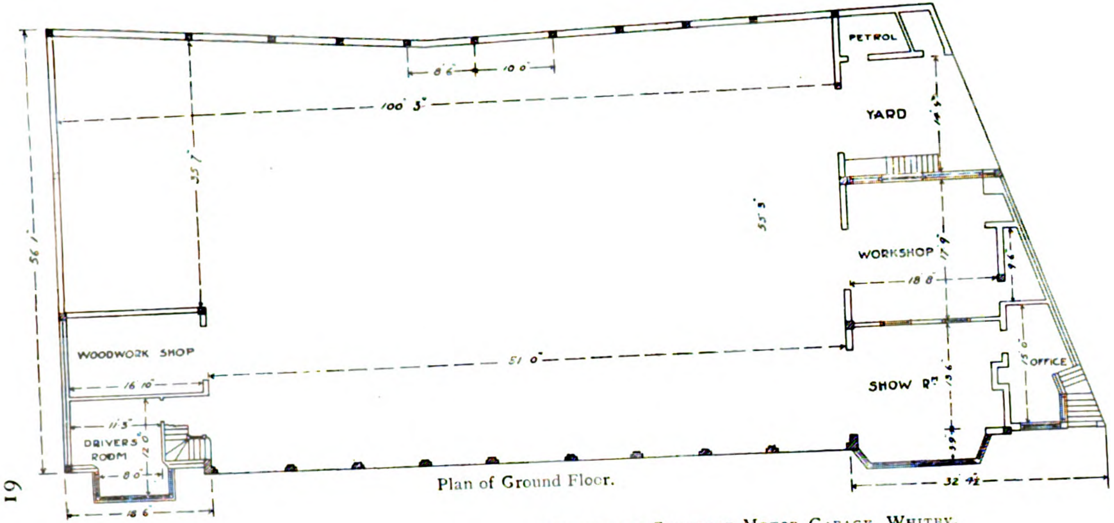
Cross Section.



First Floor Plan.

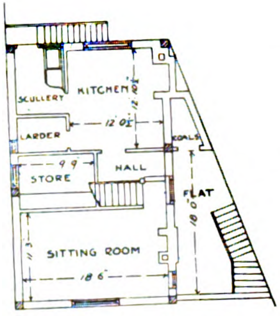


Second Floor Plan.



Plan of Ground Floor.

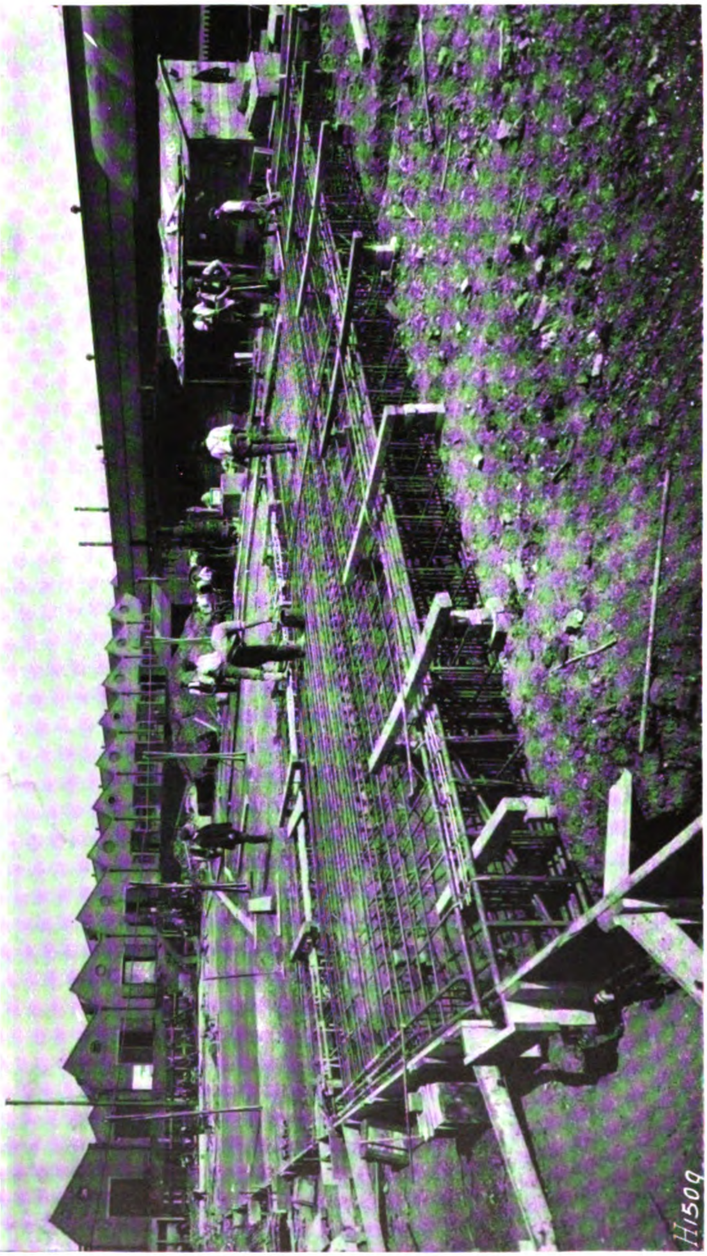
Reinforced Concrete Motor Garage, Whitby.



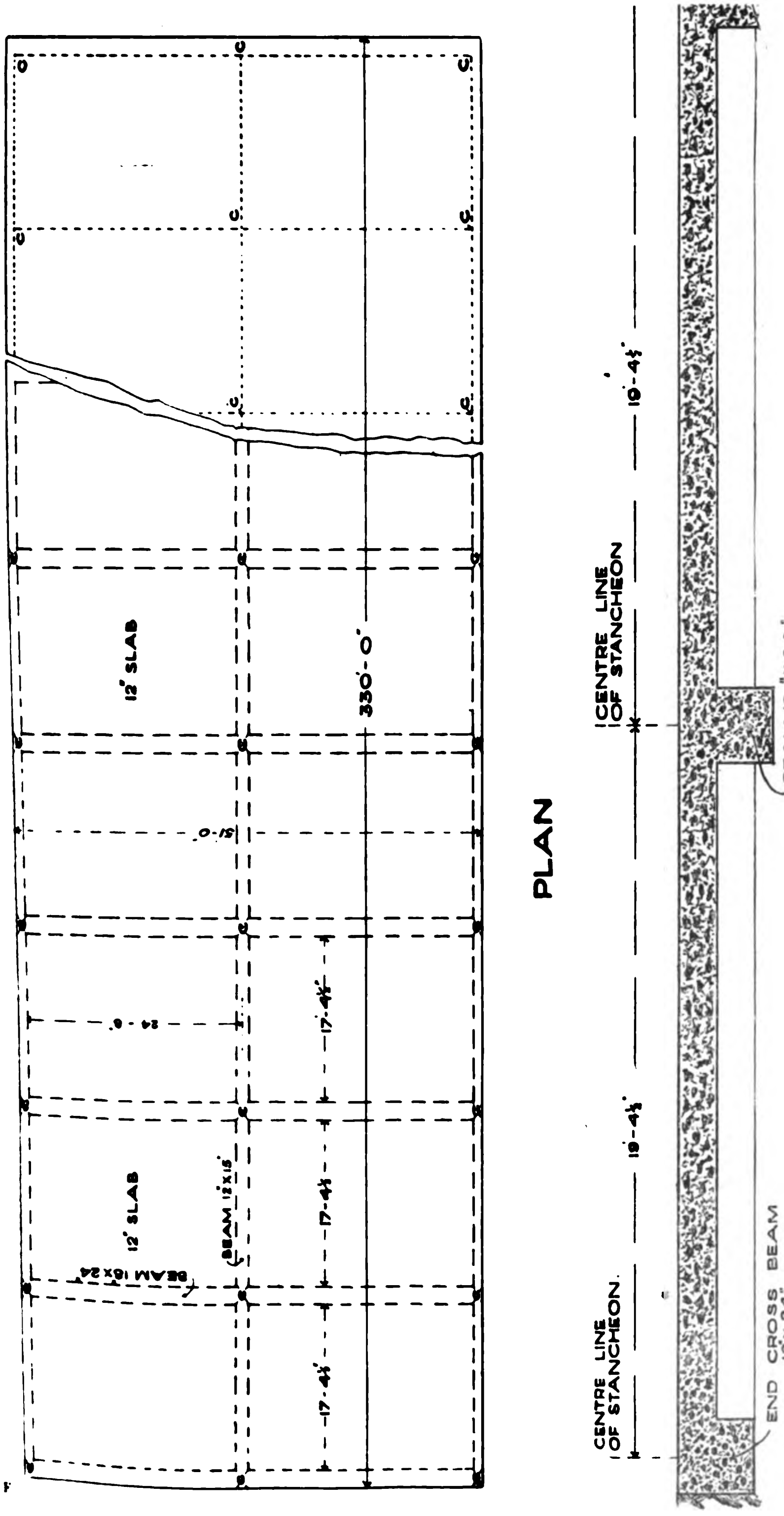
First Floor Plan.

REINFORCED CONCRETE RAFT AND FIRE-RESISTING FLOORS IN THE FACTORY EXTENSION FOR THE WOLSELEY TOOL AND MOTOR CAR CO., BIRMINGHAM.

THIS extension includes a new paint shop, consisting of a three-storey building, 330 ft. by 50 ft., and a new factory at Arden Works, approximately 446 ft. by 40 ft. wide, which is also a three-storey building.



Reinforced Concrete Raft in course of Construction.
EXTENSIONS FOR THE WOLSELEY TOOL AND MOTOR CAR CO., BIRMINGHAM.

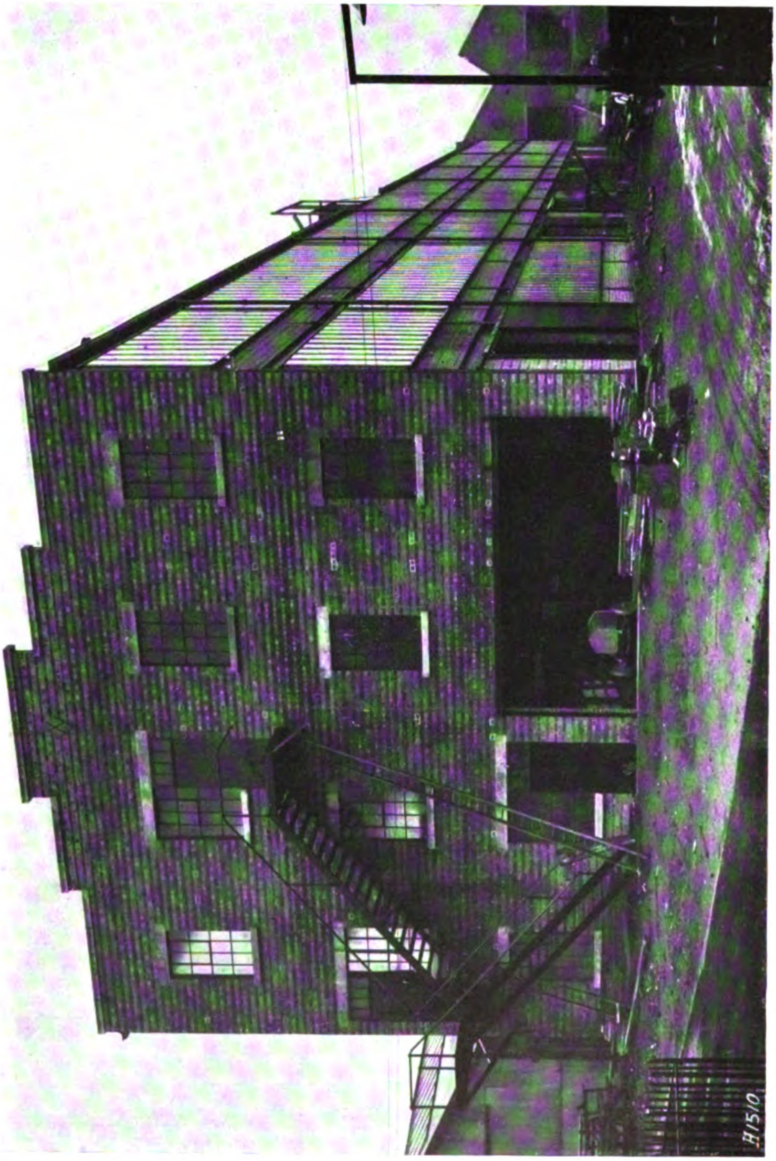


Reinforced Concrete Raft for Paint Shop.

EXTENSIONS FOR THE WOLSELEY TOOL AND MOTOR CAR CO., LTD., BIRMINGHAM.

The site for the new paint shop being on an old clay pit, filled in with rubbish, it was found that ordinary concrete footings would not be satisfactory.

After a number of tests had been made to ascertain the carrying capacity of the earth, it was decided to adopt a reinforced concrete raft, which would evenly distribute the load over the whole of the site, putting a maximum pressure of a little over 4 cwt. per square foot on the foundation.



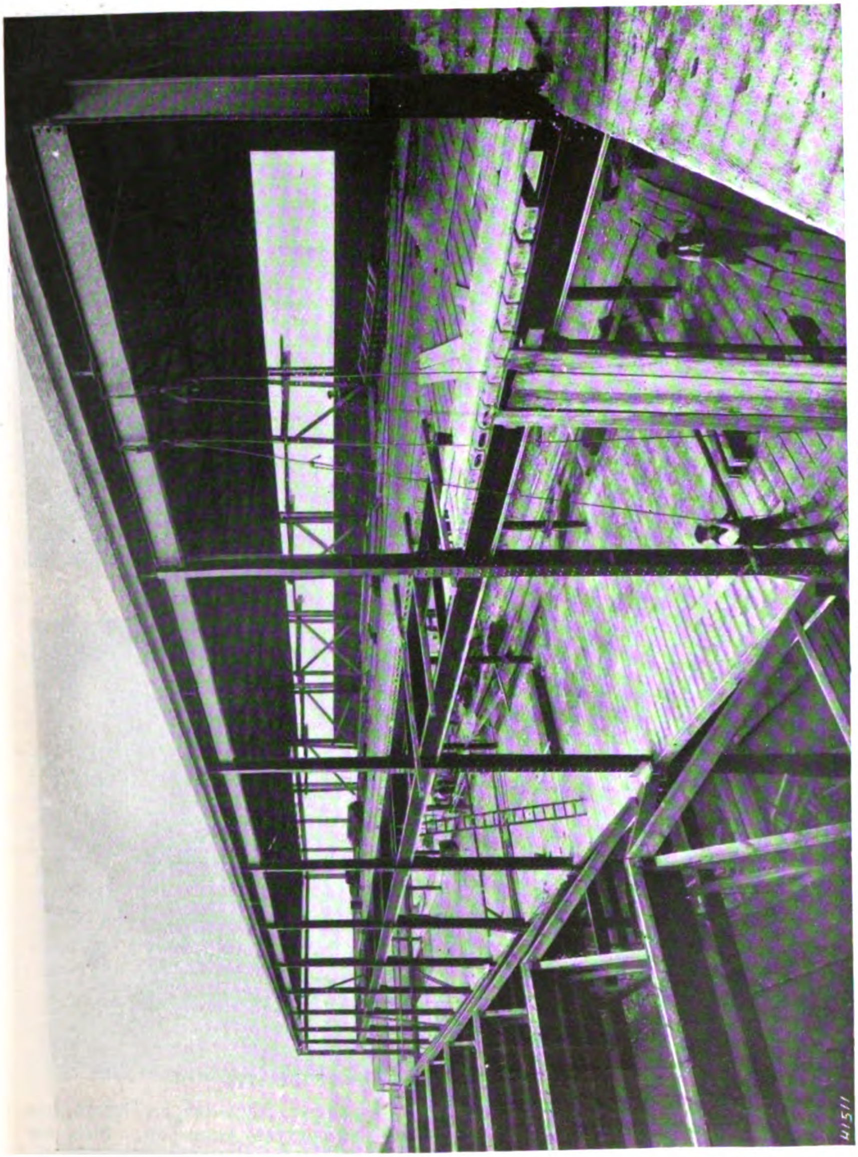
General View of Paint Shop.

EXTENSIONS FOR THE WOLSELEY TOOL AND MOTOR CAR CO., BIRMINGHAM.

The building is a steel frame structure with thin curtain walls, so that the whole of the loads are concentrated at points 25 ft. from centre to centre in the other.

From the plan it will be seen that the raft consists of a continuous slab, covering the whole of the site, and spanning between the inverted beams, which, in turn, span between the column marked "C."

The top surface of the slab was finished with a granolithic face and forms the ground floor of the factory.



View showing Siegwart Floors in course of Construction.

FACTORY EXTENSIONS FOR THE WOLSELEY TOOL AND MOTOR CAR CO., BIRMINGHAM.

The suspended floors at the new factory, Arden Works, and the flat roof at the paint shop were constructed in hollow Siegwart flooring.

Part of the floors were constructed to carry a live load of 6 cwt. per foot super, and the remainder $1\frac{1}{2}$ cwt. per foot super, while the flat roof was constructed to carry $\frac{3}{4}$ cwt. per foot super.

The great advantage claimed for the Siegwart flooring is that no centring is necessary, and so the work, *in situ*, is reduced to a minimum.

As will be seen from the accompanying illustrations, the hollow beams are brought to the site in a thoroughly matured condition, ready for fixing.

These beams are placed side by side on the supporting steel joists and the joints then grouted in with cement mortar when the floor is fixed complete.

The architect for this work was Mr. J. J. Hackett, M.S.A., of Birmingham; the contractors for the reinforced concrete raft were the Empire Stone Co., Ltd., of London; while the floors were carried out by the Siegwart Fireproof Floor Co., Ltd., of London.

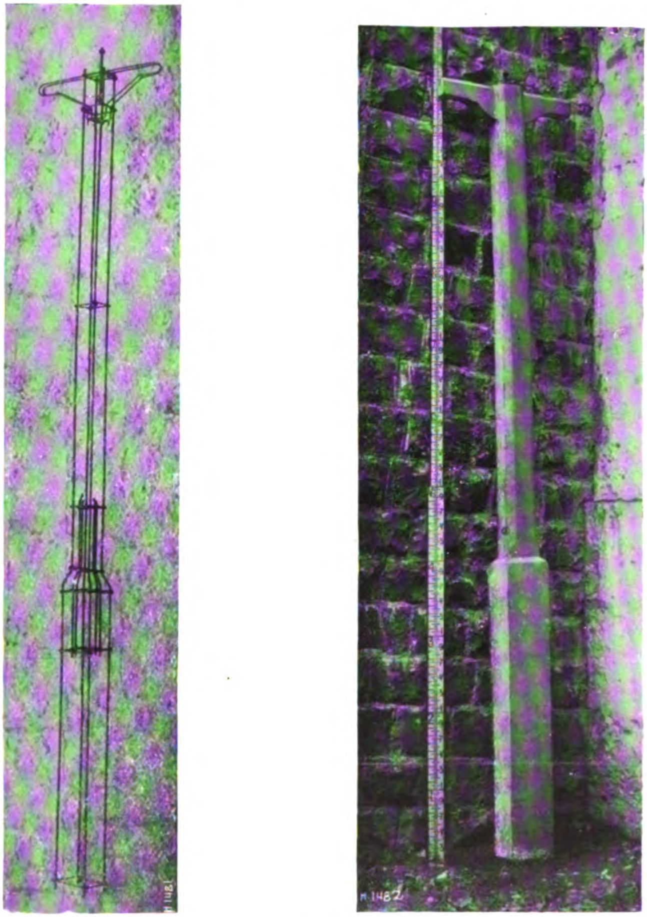


Fig. 1. Reinforcement. Fig. 2. Finished Post.

REINFORCED CONCRETE LAMP POSTS.

REINFORCED CONCRETE LAMP POSTS.

CAPTAIN D. OGILVY, Assistant Commanding Royal Engineer, Ahmednagar, Deccan, has recently designed and constructed a type of reinforced concrete lamp post, which, for simplicity of design, facility of manufacture, and low cost will be welcomed by engineers to small urban councils at home and in the Colonies, and to cantonment authorities in India.

The accompanying four photographs will, it is hoped, make its general design and mode of construction clear.

Fig. 1 shows the armouring, which consists of four mild steel roads, $\frac{3}{8}$ in. diameter, suitably tied with $\frac{3}{16}$ in. diameter bracelets. The projecting arms (to support a "lamp lighter's" ladder) have a double reinforcement of $\frac{3}{16}$ in. or $\frac{1}{4}$ in. diameter rods. The bolt which secures the familiar lamp cradle is also shown, also four extra $\frac{3}{8}$ in. rods are given where the plinth merges into the main column to resist any undue transverse strains during erection.

Fig. 2 shows the finished post. Its cost, fixed in position, is 12s. Cement cost 12s. per barrel (400 lb. net), and mild steel rods 10s. per cwt.

Figs. 3 and 4 show the moulds, which consist of $\frac{1}{4}$ in. mild steel plates, each taking two posts laid head to foot. The shuttering of 1 in. Burma teak are fixed down by iron straps and bolts to these pallets. As the post plinth is 7 in. by 7 in., and the column 5 in. by 7 in., the reduction of 1 in. is effected by telescoping side shuttering and by fixing a 1 in. plank underneath the column.

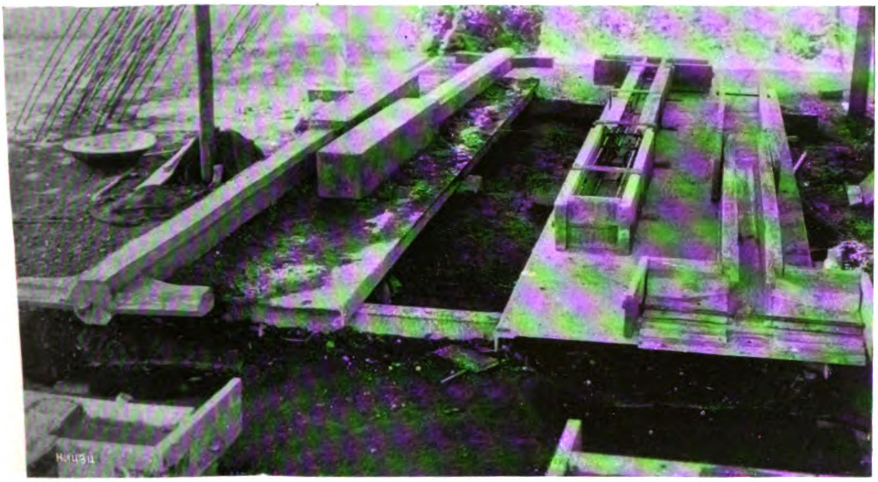


Fig. 3. Moulds with and without Reinforcement.

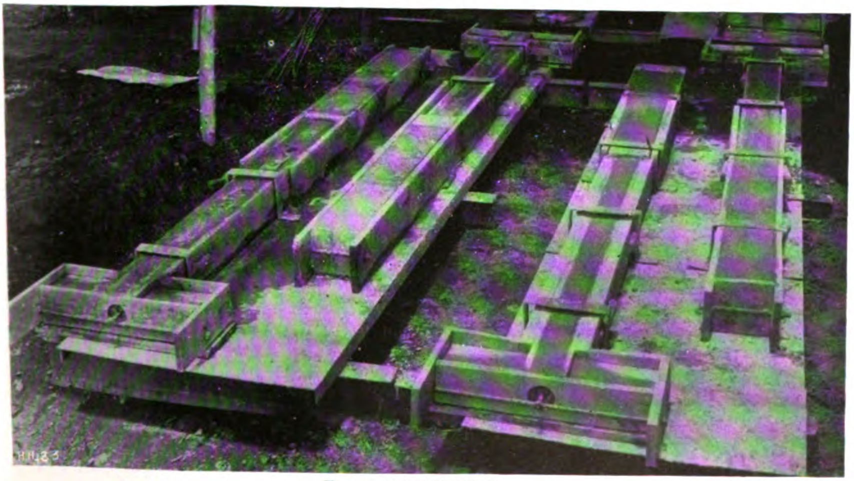


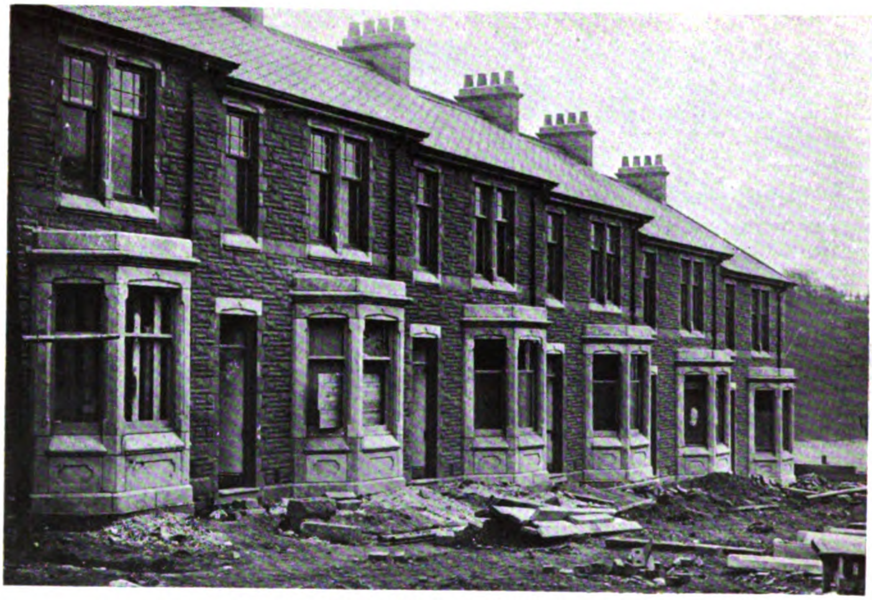
Fig. 4. Moulds filled.

REINFORCED CONCRETE LAMP POSTS.

The proportions of cement, sand, and aggregate are 1 to 2 to 4 (by volume). The sand is a finely graded quartz. The aggregate, which is graded from $\frac{3}{8}$ in. to $\frac{1}{8}$ in., is shingle obtained from neighbouring ravines, consisting of many kinds of igneous rock.

CONCRETE BLOCK HOUSES AT NEWBURN-ON-TYNE.

The accompanying illustration shows part of twenty-four concrete block houses in course of erection at Newburn-on-Tyne by Messrs. The Blaydon District Industrial and Provident Society, Ltd., for their members. This Society had already erected 48 similar houses at Blaydon-on-Tyne and these were so readily taken up it was decided to proceed with a further number.



CONCRETE BLOCK HOUSES AT NEWBURN-ON-TYNE.

The houses vary in size, having sitting-room, kitchen and scullery, or combined kitchen and scullery, two, or three bedrooms, bath-room with hot water system and conveniences in yard, and vary in price from £500 each downwards.

The houses were designed by Mr. Wm. Crooks, Junr., Architect, Blaydon-on-Tyne, and are built throughout with blocks made on one "Winget" machine purchased by the Society.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

The Glasgow Text Books. Edited by G. Moncur.

"Reinforced Concrete Railway Structures." by J. D. W. Ball, Assoc.M.Inst.C.E., A.C.G.I.

London: Constable and Co., Ltd., 10, Orange Street, Leicester Square, W.C. 213 pp.+xiv. 1913. Price 8/- net.

It is sometimes said that of all British engineers, those who control our railways have been the most reluctant to adopt reinforced concrete. Mr. Ball in this work gives reasons for this cautious attitude, and he wisely advocates its use in the best possible way—not by preaching reinforced concrete in season and out of season, but by showing where it is of the greatest service to the railway engineer, and, on the other hand, where its older rivals still hold their own. After reading his book one is struck with the variety of ways in which reinforced concrete can be used in railway work with the greatest convenience and with true economy.

In the first chapter, on "Preliminary Considerations," this question of the convenience and economy of reinforced concrete is discussed, and an interesting comparison is given between a floor designed as a reinforced concrete Tee-beam and one designed in the older manner with steel joists and concrete filling. Estimates of costs are given in each case, which show a clear advantage in the newer type of construction. In the same chapter the quality of the component materials—concrete and steel—and the permissible stresses to which they should be subjected, are briefly dealt with.

Chapters 2 and 3 deal with the theory of Bending and Shear Stress, and contain a really useful enquiry into the subject of the most economical proportion of steel to concrete in a beam, having regard to the actual costs of these materials.

Chapter 4 deals with Floors and Buildings, and incidentally gives an example of a floor reinforced with old rails. On railway works this is a cheap form of steel, but it should be pointed out that if rails are used careful investigation should be made into the bond stresses, as rails are weak in this respect and difficult to anchor.

Chapter 5 deals with Foundations and Rafts. One of the most useful applications of reinforced concrete is in the formation of rafts or foot-blocks under heavy walls and columns, and the calculations required to design such rafts are given at some length.

Chapter 6, on Retaining Walls, will be of great interest to railway men. It is pointed out that in many cases the old-fashioned gravity wall will prove cheaper than one made with reinforced concrete. The necessary calculations for the strength of L-shaped walls are given and explained. The stability of this type of wall is also touched upon. But it is curious that this work, like so many other text-books on retaining walls, omits altogether to consider the most common weakness of all these structures, viz., their tendency to slide forward on their bases. An L-shaped wall, with its horizontal limb turned outwards, is described, and it is shown that it is secure against overturning and against crushing the ground beneath it; but nothing is said about its tendency to slide forward, and this wall certainly would do so if built on a slippery foundation.

Chapter 7, on Bridges, gives many interesting examples and an original investigation into the stresses induced in beams with sloping ends, such as are commonly used for station footbridges. An example of a railway underbridge is very briefly described, so briefly that the reader wishes for some further information on this type.

Chapter 8, on Arched Bridges, contains complete calculations of the stresses in two-arched overbridges of 40 ft. span.

The last chapter, on Sleepers, Fence Posts, etc., contains a most interesting enquiry which the author has made into the subject of the stresses induced in railway sleepers, and explains the difficulties attending the use of reinforced concrete in their manufacture.

We are disappointed to find that the author has not adopted the standard notation put forward by the Concrete Institute. It is a great help when the symbols used are familiar to the reader, and we hope this defect will be remedied in later editions. We should like also to see the subject of live loads more fully dealt with. The effects of heavy rolling loads, and the provision that should be made against them in the way of shear and bond strength, are subjects of the highest importance to the railway engineer, and deserve a chapter to themselves.

The book is well illustrated, and, besides giving prices, in some cases the author has added extracts from the specifications, which will be found of service. We feel sure that this is a work which will be read with interest by every railway engineer, and especially by those who desire to study what has been accomplished in reinforced concrete.

"The Strength of I-Beams in Flexure." By Herbert F. Moore

Published by the University of Illinois Arbana. European Agent, Chapman & Hall, Ltd., London. 40 pp. Price 20 cents.

Contents.—Phenomena of Flexural Failure—Earlier Tests of I Beams—I Beam Tests at the University of Illinois—Yield Point of Structural Steel in Tension and Compression—Failure of I Beams by Direct Flexure—Inelastic Action of I Beams under Low Stress—Buckling of Compression Flanges of I Beams—Tests to Failure of Beams Restrained from Twisting of Ends and Beams Restrained from Sidewise Buckling—Effectiveness of Sidewise Restraint of I Beams—Web Failure of I Beams—Stiffness of I Beams—Summary.

These notes are published in the form of Bulletin No. 68 of the University of Illinois, and are an addition to the useful literature that has already been published by the University dealing with the research work of the department which is under the supervision of Professor A. N. Talbot.

The various tests that have been made are important, as they deal with a form of member which is so extensively used, and they have been conducted with a variety of method that is likely to cover those conditions which obtain in practice. The author states in the Summary that the separators commonly used between the webs of I beams do not furnish a stiff bracing against sidewise buckling, and great stress is laid on the importance of regarding the yield-point strength and not the ultimate tensile strength, as the ultimate fibre stress for structural steel in flexure. The various tests are clearly explained and presented in such a manner that the results and recommendations are readily available to the reader. The notes and tests dealing with beams which were restrained are of particular interest, and we have no hesitation in recommending this little book to our readers.

"Handbook of Structural Steelwork."

Redpath, Brown & Co., Ltd., 1913.

This handbook gives in a convenient form the necessary general and detailed information required in the designing of structural steelwork, and will be found most useful to all those interested in the subject. The book is arranged in parts, each having a contents page and containing notes and formulæ explaining in detail the tables to which they refer.

Part IV. contains a very clear explanation of the main principles of steel structural design.

Part V. gives suggestions and details of construction with standardised connections, and by attention to these in designing steel buildings considerable economy may be effected. A selection of compound girders is given obviating the making of numerous minor calculations.

In compiling the parts attention has been paid to the Acts governing steel construction.

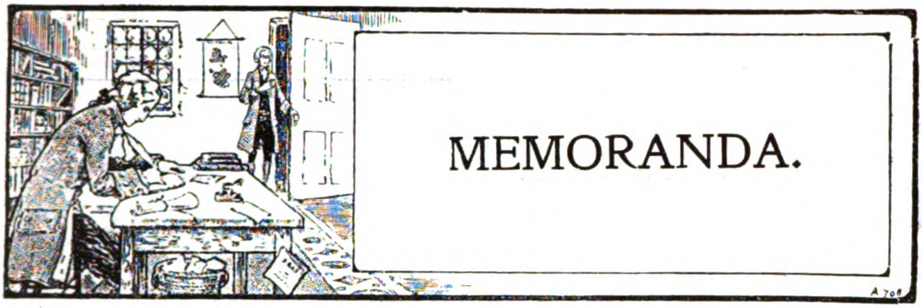
The whole of the definitions given are very clear and easy to follow, and the various tables are well arranged.

"Clerk of Works."

G. Metson. Price 2/6.

This handbook deals with the duties of a Clerk of Works. It will be found of great help, chiefly to those taking up the position of Clerk of Works for the first time.

Those with previous experience of the duties will probably gain some valuable hints from reading the book, which instructs and also makes clear what is required of an efficient Clerk of Works.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Concrete Institute.—A paper was read last month by Mr. Lawrence Gadd, entitled "Some Fallacies in Testing Cement." A report of the paper and discussion will be published in our next issue.

Newcastle Civil Engineers Students' Association.—An interesting address was some time ago delivered at the opening of the winter session of the above Association by Mr. C. H. Sandeman, M.Inst.C.E. In the course of his remarks the lecturer referred to the atmospheric influences on concrete. He stated that its failure in sea water in the past had been due to incorrect proportioning and mixing. Very great care was necessary in the measurement of proportions, and in the quantity of water used. Unfortunately, despite an improvement of late years, there was still a great laxity in these respects, and one was inclined to fear for the future of some important sea works now being constructed.

No other material, he concluded, offered such complete protection to iron and steel as cement, and no material was more permanent than properly made concrete, so that he looked forward with confidence to the extension of its use, in intimate combination with steel, in almost every class of engineering structure.

Fourth International Congress of Building and Public Works.—We are asked to announce that this Congress will take place at Berne, August 23rd to 27th this year, under the auspices of the Swiss Federal Government. It is hoped that the Congress will be a thoroughly representative one, as important questions will be brought forward for discussion. A full programme will be issued by the Organising Committee at a later date. The headquarters of this Committee are at 13, Seidengasse, Zurich.

Fire-Resisting Concrete.—Of recent years complete confidence has been established in the fire-resisting qualities of properly constructed concrete, says the *Canadian Engineer*. These, combined with its durability and strength, render it particularly suitable for the construction of buildings in which more or less hazardous occupations are to be carried on, or which are to be erected in areas wherein it would be difficult to cope with a conflagration.

For fire-resisting concrete quartz sand should be used, and broken trap rock is, perhaps, more suitable than any other substance. Limestone is probably next in order of suitability, although it will eventually run into a crude form of glass or be calcined; but that will not take place until the cement itself has been disintegrated. Contrary to the commonly received opinion, cinder concrete is not unsuitable from a fire-resisting point of view. The chief objection to its use is that it is far from strong. Heat does not affect it to a great extent; indeed, it has been found that small pieces of coal embedded in concrete have remained entirely unaffected by heat. That was due to the low heat conductivity of concrete; indeed, it might almost be said that it is an insulator of heat—so much so, at any rate, that the hand can be borne on the top of a slab of concrete 5 in. in thickness under which a fierce fire has been raging for five hours or more.

This non-conductivity is well shown by the following account of a steam conduit built of concrete. The conduit was about 500 ft. long, and was built between a mill and a boiler-house, and was made just wide enough to take two steam pipes 6 in. in diameter and two smaller pipes. After the pipes had been laid in position a concrete cover was constructed over them, so as to render the conduit proof against any moisture

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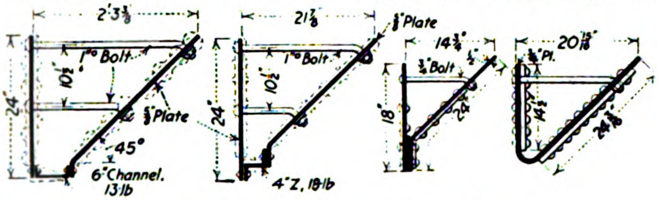
in the soil or surface water. The conduit was carried some 2 ft. 6 in. below the surface—not sufficiently deep to be beyond the influence of the specially heavy frosts which were periodically experienced in the neighbourhood in which the conduit was laid. The concrete troughing was left open at both ends, to make it easy to ascertain whether there was or was not any leakage. It was assumed that if any vapour was found to escape from either end of the conduit there must be some leakage which would permit the water to vaporise. The conduit was allowed to dry thoroughly, which took about two weeks; but no vapour has at any time been visible, and the loss of heat, which has been measured, through the concrete is so small as to be negligible.

Steel-Cutting Edges for Concrete Caissons.—Reinforced concrete caissons sunk through rock form the foundation for the main part of the Tennessee River dam at Hales Bar, Tenn. There are 26 caissons in all, in sizes from 30 by 32 ft. to 54 by 70 ft.; in sinking them there was opportunity for trying variations in design. Several types of cutting-edge were tried, sketched herewith. It is stated by the engineers in charge of the contract work that the last one sketched, the round cutting-edge, proved greatly superior to the others; this, of course, applies to *work in rock* only.



FOUR FORMS OF CUTTING EDGE FOR CONCRETE CAISSONS.

The rock under the cutting-edge was removed mainly by blasting. An important matter was to clear the rock away well outside the outer line of the caisson, as otherwise a projecting point might hang up the caisson. The round-edge style of cutting-edge was the best adapted to this requirement, whereas the flat-bottom styles, especially the first one (6-in. channel base), gave considerable trouble in clearing.

Blasting with light charges was done close to and right under the cutting-edge in all the caissons, but in no case damaged the cutting-edge. The explosive was 60 per cent. dynamite.—*Engineering News.*

Harbour Work in Belgium.—As a first step towards improving the port of Nieuport, at the mouth of the Yser, the only natural port on the Belgian littoral, works involving an estimated expenditure of 1,700,000f., are shortly to be undertaken.

According to the plans the existing floating basin is to be lengthened and improved by the construction of reinforced concrete landing-stages, and a second head towards the sea at the lock giving access to the floating basin will form a chamber-lock permitting vessels to enter or leave at all stages of the tide. A diversion of the old western branch of the Frunes Canal is to be constructed, which will cause the water from the interior, now flowing into the harbour through five locks, to flow directly into the sea. Improvements are also to be carried out in the roadstead of the port.

The Department of Public Works has decided to undertake the construction of a sea dam between Knocke and Duinbergen for a length of 2,009m. Including the necessary staircases (28 in number) to give access to the sea, the cost will be about 700,000f. The work is to be completed within 26 months.—*Times.*

Self-Supporting Concrete Towers.—Two self-supporting concrete towers with 90 ft. booms are being used to distribute mixed concrete for an eight-storey, basement, and sub-basement reinforced concrete building now being erected at St. Paul, Minn. The building is 100 ft. by 288 ft. in plan, with the mushroom type of reinforcing, and requires 15,000 cubic yards of concrete. As permission from adjoining property owners to attach guy wires to their buildings could not be obtained, the towers had to be built with sufficient stability to stand alone.

Next to the building an ordinary tower, made of heavier timber than usual, was erected. In the rear an auxiliary tower, 10 ft. by 16 ft. in plan, was built to a height of about 70 ft. The main tower will, at the time the building is completed, reach about 175 ft. above the pavement. To counterbalance the weight of the boom and three shutes, which are suspended by cables, the rear tower is weighted with stone, its own weight not being sufficient to serve as an anchorage. Within the rear shaft is an elevator skip on which loaded wagons are driven and materials dumped. After the team is driven off the material is hoisted and automatically dumped into elevated bins at one side of the auxiliary tower. A rectangular timber frame, sliding on the two front timbers of the main tower as guides, carries the boom and shutes on a pivoted connection. To raise the frame a block and tackle is fastened to an overhanging timber extending from the main tower, a lead running therefrom to the hoisting engine. The circle of these booms is sufficient with the small pivoted shutes at the ends of the main shutes to cover the whole area, and a hopper, carried in a sling in the main shaft, is raised or lowered to a point opposite any one of the three shutes. Two mixers are placed directly under the material bins at the level of the second bend of the main tower, so that it is unnecessary for the elevator buckets to be lowered quite to the street level.

Reinforced Concrete Water-tank of 600,000 gallons Capacity.—A reinforced concrete water-tank and tower have recently been constructed at Berlin, Ont., Canada. The tank has a capacity of 600,000 gallons when the water-line is 2 ft. below the top. It is 50 ft. in diameter, 40 ft. high, and is formed of a circular shell 12 in. thick at the bottom and 8 in. at the top, standing on a reinforced concrete tower 81 ft. high from the footings of the foundation. The tank is covered with a flat-arched dome of reinforced concrete 4 in. thick, and the bottom is made up of two domes which run into each other, the outer one being inverted, with its low part resting on the supporting tower, from which point springs the inner dome, which is convex to the inside of the tank. The bottom is well reinforced to prevent bulging. The inner and outer domes of the bottom are so proportioned that the thrusts nearly balance. The thrust at the junction of the bottom and the shell of the tank, due to the weight of the shell and its roof, is provided for by a large amount of steel reinforcement. The tank reinforcement consists of ⅞ in. and ¾ in. square bars of high carbon steel, placed in two separate layers where the spacing was less than 4 in. In the inner dome of the bottom there are ½-in. rods spaced from 6 in. to 8 in. apart, centre to centre. Concrete, mixed in the proportion of 1 : 1 : 2, was used in all portions of the tank in contact with water, whereas the proportion in all other places was 1 : 2 : 4. As a means of waterproofing the tank, three coats of mortar, gauge 1 of cement to 1 of sand, and laid on ¼ in. thick, were used.—*Engineering Record.*

ERRATA.

The writer of the article on "London's Reinforced Concrete Regulations" points out that in the first part of the article published in our issue for August there is an error in calculating the deflection of a steel beam. It should be :—

$$\Delta = \frac{5}{48} \times \frac{7{\cdot}5 \times l^2}{13400 \times l \div 48} = \frac{1}{357} l$$

As a consequence of this, the references to the limiting deflections on pp. 534 and 535 require modification.

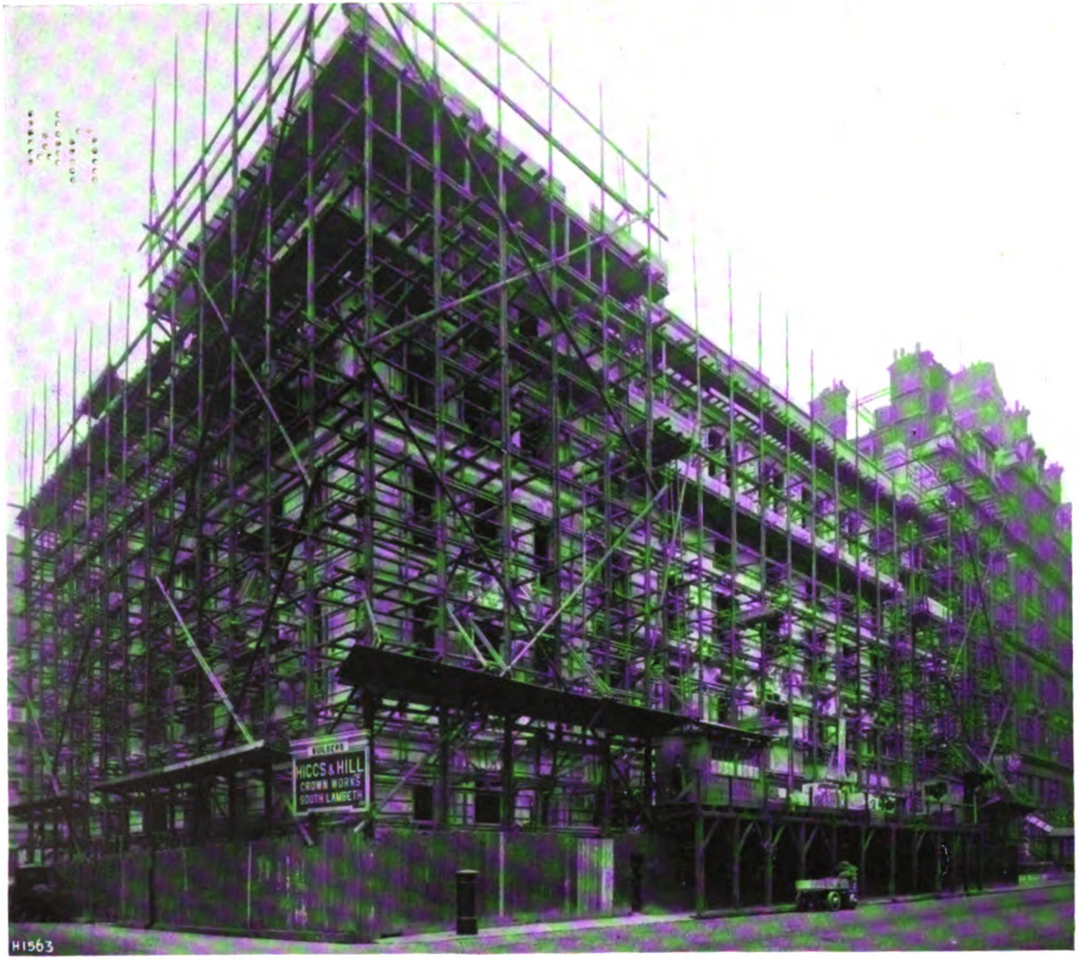
Concrete Institute Presidential Address.—In reporting the remarks made by Professor Henry Adams (*page* 847 *of our December issue*), the words given as air slaking should have read "over slaking."

CATALOGUES RECEIVED.

Richard Johnson, Clapham & Morris, Ltd.—A new catalogue has recently been published by the company's reinforced Concrete Department. Full descriptions are given, accompanied by illustrations of the Keedon and Johnson Lattice system, both of which are well known to our readers. The book also contains some excellent illustrations of actual work carried out by the company.

Especial attention must, however, be drawn to the carefully compiled and very extensive tables, which are intended to assist engineers, architects, and others in fixing sizes for preliminary designs, and enabling them to arrive at the sizes of superstructure without difficulty. Messrs. Johnson, Clapham & Morris desire us to state that they are, of course, prepared to supply all necessary detailed drawings, and to add further details not specified in the tables. They will gladly forward this book and give all further information upon application to them at their offices, 24 and 26, Lever Street, Manchester.

The Standard Steel Co., Ltd.—This company has recently issued a handbook of structural steel which will doubtless prove useful to architects, engineers, builders, and others. Every attempt has been made to arrange the tables in such a manner that any information needed can be easily found without having recourse to numerous calculations. The booklet contains tables for rolled steel sections used as beams, broad flange beams, rolled steel channels used as beams, steel angles used as beams, steel compound girders, etc., etc. There are also useful tables for various kinds of columns, both hollow and solid. The booklet also contains tables of weights of different forms of steelwork, as also various diagrams and illustrations. Copies of this handbook can be obtained from the company at their offices in Croydon.



Photograph by Ernest Milner, Wandsworth, S.W.

NEW OFFICES FOR THE BOARD OF AGRICULTURE AND FISHERIES.

(For description see page 77.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume IX. No. 2. LONDON, FEBRUARY, 1914.

EDITORIAL NOTES.

LABOUR TROUBLES AND CONCRETE.

THE regrettable differences that have arisen between employers and employed in the building trades must necessarily have serious effects upon the skilled labour market concerned in the erection of buildings. Whilst we fully sympathise with the principle of the working man having his trade unions to protect his interests and rendering services as a benevolent society, we are afraid that the policy of some of the leading agitators is quite suicidal to the interests of the man who has learnt a trade, and it is certainly not equitable in the matter of demands against the use of free labour. But from the purely selfish point of view, as advocates of the use of concrete and reinforced concrete, we see in this new struggle between employers and employed great advantages for the development of the concrete and cement industries. We have only to remember the quarrel of some ten years back as between the Plasterers' Union and the builders, to see how detrimental that quarrel was for the plasterers and what an excellent thing it was for the concrete industries, for it is from that date that we have had the enormous development of the concrete slab and the concrete block for partition purposes and many other building requirements, which were formerly catered for by the skilled plasterer.

The new strike will simply lead to a greater use of concrete for footings, walls, floors, hearths, lintols and roofing, and the bricklayer, the joiner, the mason, the slater and the tiler must be materially affected.

This is regrettable for these particular trades, for they contain some of the very best elements of the British artisan class; but, to repeat, the concrete industries must gain, and unskilled labour in particular will naturally reap a large benefit, for concrete work employs vast numbers of unskilled labourers, excepting in certain forms of reinforced concrete. These men need have but little experience, and concrete mixing is one of the simplest forms of labour open to all unemployed.

It has often been commented upon what enormous strides concrete has made, both in the United States and in Canada, and economy is generally given as the reason; this is true up to a point, and it is certainly true in respect of larger buildings, but in small buildings it does not necessarily always happen to be the case, and the great advantage accruing to the employer who is free from the trammels of trade unionism has played no small part. Thus, whilst the large majority may think the coming strike a great evil for the building trade, we see in it a future for more economic buildings and less labour troubles, combined with the greater possibility of using unskilled labour to get up a building rapidly.

RESEARCH WORK AND CONCRETE.

In our Memoranda we announce the formation of a British Section of the International Association for Testing Materials, and we congratulate the promoters, and particularly Professor Unwin, Mr. Leslie Robertson and Mr. Lloyd for their successful efforts in this direction.

We trust the British Section is the forerunner of a *British* Association for Testing Materials, similar to that excellent institution which exists in the United States, and similar to other institutions that exist on the Continent. It is regrettable indeed that we should, up to the present, not have had any real centre for research work affecting constructional materials, and whilst other nations have long had their sections or individual associations, and have been doing good and continuous work enquiring into matters of the utmost importance, we have practically marked time.

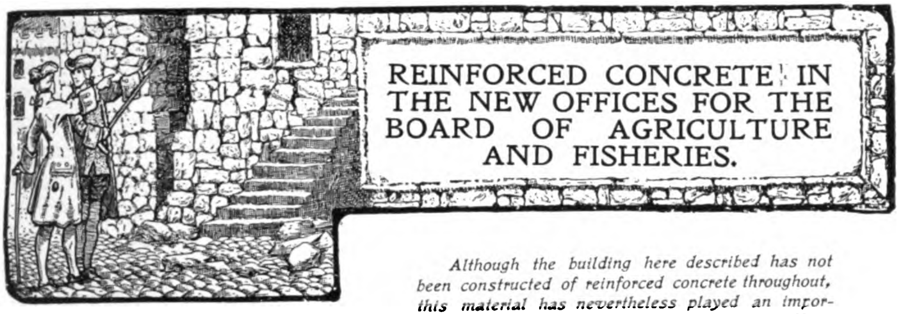
Some work has, of course, been done at the National Physical Laboratory, mainly at the instance of certain institutions, and notably lately at the suggestion of the Institution of Civil Engineers on the matter of reinforced concrete. For consecutive effort in research on constructional materials, we have, in this country, really only the British Fire Prevention Committee, with its somewhat limited scope in relation to materials affording fire protection.

With the British Section of the International Association for Testing Materials, duly formed—and, we trust, a National Association in embryo—we hope the necessary funds may be collected to enable research work to be done, so that we may not continue to take a back seat in the comity of nations in this particular department of investigation. The subject is all-important for concrete, reinforced concrete, and particularly cement, all relatively new subjects, and a vast amount of experimental work is needed. This work should be carried out on practical lines, rather than on the ultra scientific lines all too frequently met with on the Continent. We again repeat that we welcome the formation of this new section.

OUR CONCRETE COTTAGE COMPETITION.

We would remind our readers of our announcement regarding a competition for concrete cottages, particulars of which will be found in our advertisement columns, and the full conditions of which can be obtained from the offices of this journal, on application to the publisher.

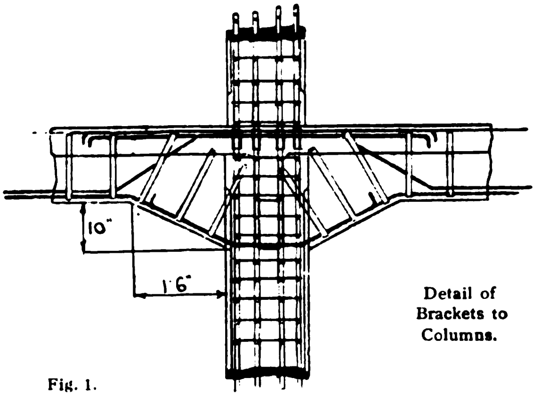
The subject of our competition appears to have awakened considerable interest, and although to many of our readers, who have already attained the more successful walks of life in their profession, competitions cannot appeal, we trust they will bring this question to the notice of their younger colleagues and the members of their staff.



REINFORCED CONCRETE IN THE NEW OFFICES FOR THE BOARD OF AGRICULTURE AND FISHERIES.

Although the building here described has not been constructed of reinforced concrete throughout, this material has nevertheless played an important part in the work. Our article has been prepared for us by Mr. Albert Lakeman, Hon. Medallist Construction.—ED.

THIS new building is being constructed in Whitehall Place for the accommodation of the Board of Agriculture and Fisheries, the various departments of which are at present scattered in different buildings in the West End, thus rendering the organisation and control more complicated and difficult. The work of the Board is very extensive, and has grown considerably during recent years, the various additional duties imposed since its establishment in 1889 including the transfer to the Board of the Ordnance Survey Department, the headquarters of which are in Southampton, the jurisdiction of the Royal Botanic Gardens, Kew, and the administration of the laws relating to the fisheries of England and Wales. The establishment for which accommodation has to be provided consists of a President, a Permanent Secretary, a Parliamentary Secretary, Assistant Secretaries, and a staff of administration and technical officials.



Detail of Brackets to Columns.

Fig. 1.

THE NEW OFFICES FOR THE BOARD OF AGRICULTURE AND FISHERIES.

The new building is being erected under the superintendence of Mr. H. A. Collins, A.R.I.B.A., one of the Architects of H.M. Office of Works. The designs were originally prepared by the late Mr. H. N. Hawks, I.S.O. The site adjoins the Hotel Metropole, and is opposite the New War Office, having a frontage of about 150 ft. to Whitehall Place, 101 ft. to Whitehall Place West, and 136 ft. to Great Scotland Yard. The total height of the building is about 95 ft. from the pavement level, and the section illustrated in *Fig.* 2 is not quite correct, as an additional floor has been added by carrying up the roof for another storey. The basement floor is 15 ft. below the pavement level, and in addition a lower ground floor is constructed 6 ft. below the same level. The plan of the basement is illustrated in *Fig.* 3, and it will be seen that a corner of this is cut off by the Regent Street sewer, which passes under the building at the level shown on the section.

This basement, which is to be utilised for workshops, packing rooms, and stores, is well lighted by large skylights, which occur at the bottom of the two large light wells which are formed in the central part of the building; while the lower ground floor is directly lighted by windows in the external walls, in addition to the interior light wells. The principal entrance to the

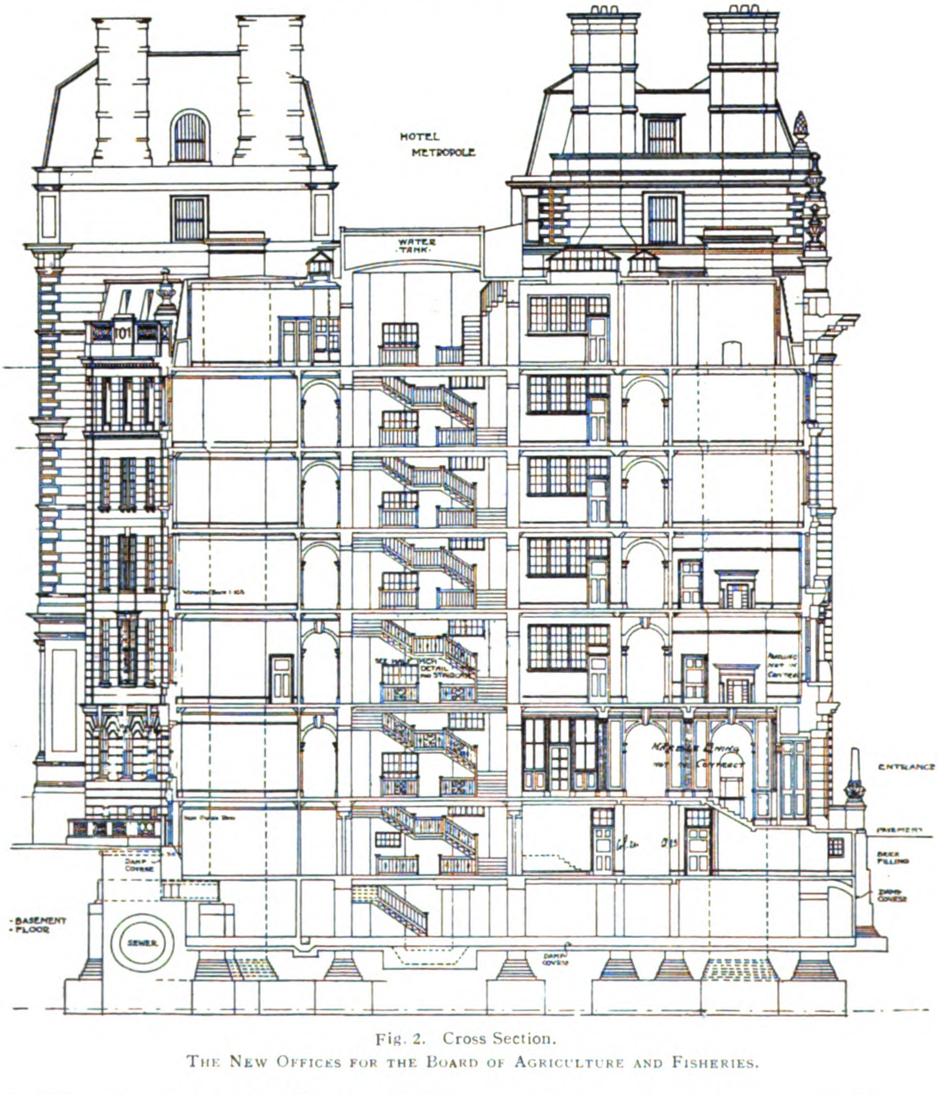


Fig. 2. Cross Section.
THE NEW OFFICES FOR THE BOARD OF AGRICULTURE AND FISHERIES.

building is situated in Whitehall Place, and the main staircase and lift are placed in the centre of the building, with direct light from one of the large areas. Reinforced concrete is largely employed in the construction of the building, and this is designed according to the Hennebique system by Messrs. Mouchel and Partners, Ltd., of Victoria Street. It is not a complete reinforced concrete building, however, as the external walls are of brickwork, the façades being faced with Portland stone; and all internal walls in which fireplaces were required were also built of brick. The loads coming on these walls are carried by blue brick piers, and the retaining walls are also of this material.

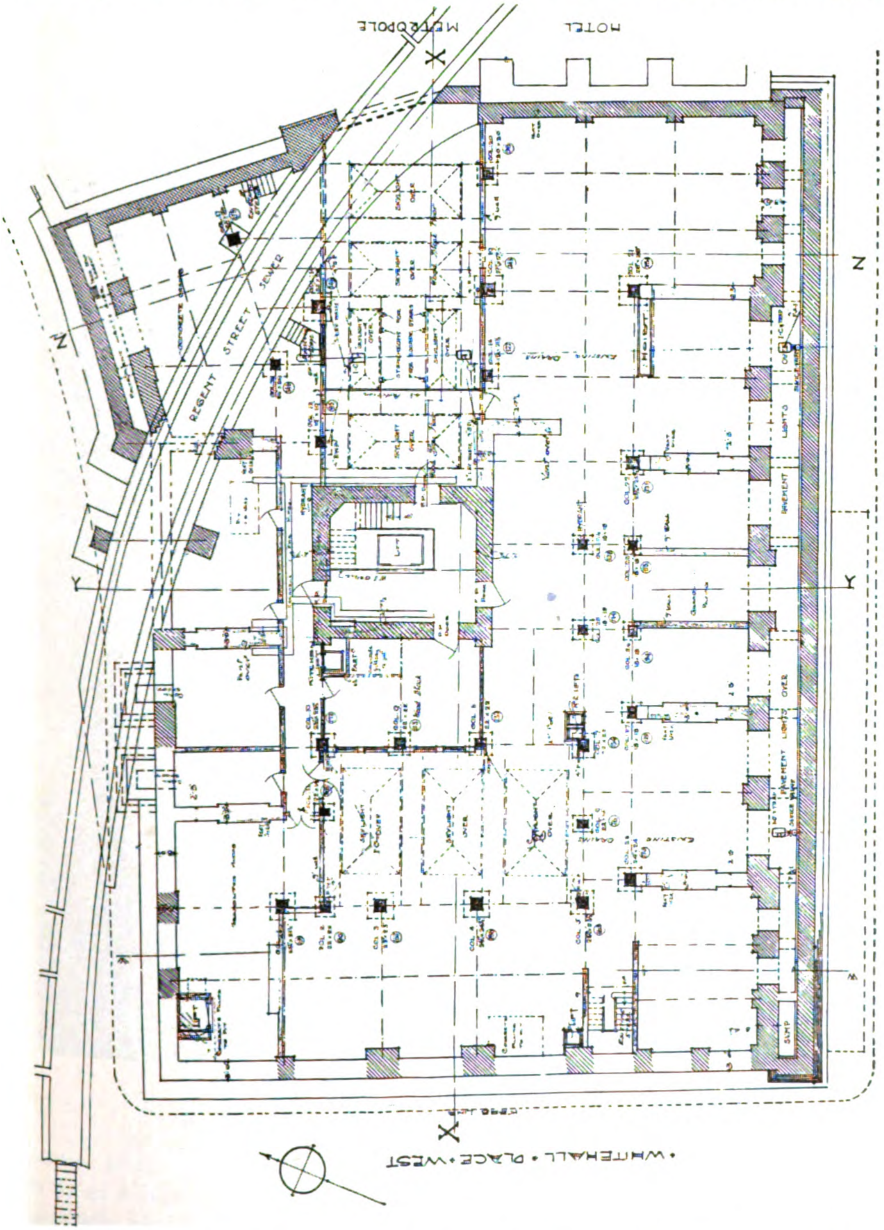
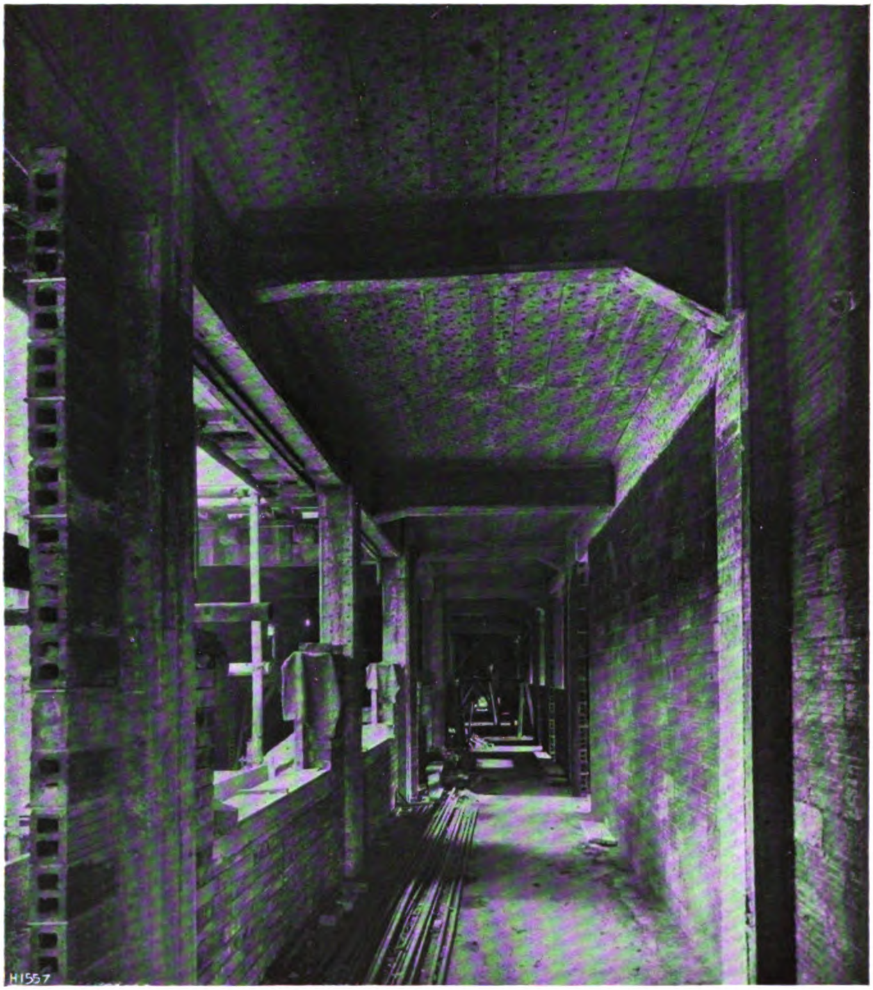


Fig. 3. Basement Plan.

THE NEW OFFICES FOR THE BOARD OF AGRICULTURE AND FISHERIES.

The reinforced concrete work consists of columns, beams, floor and roof slabs, and staircases. Trial holes were made on the site to ascertain the nature of the soil for foundation purposes, and these showed old brickwork and concrete, mud, sand and clay to depths varying from 20 to 25 ft. below the pavement level, and below this a layer of gravel was found, varying from 12 ft. to 20 ft. in thickness, overlying the blue clay; whilst water was encountered about 27 ft. from the surface. A concrete raft was constructed over the whole site, this being in two thicknesses, the bottom of which was 6 in. thick and the upper layer 1 ft. 6 in. thick, with a continuous asphalt damp course between. This asphalt was taken through the surrounding walls and carried up on the outside to form what is practically a large asphalt tank, in which the building is constructed. The raft is covered with paving to form the basement floor and the retaining walls, and 9-in. interior division walls are built directly on to the raft which forms the foundation; while the foundations of the main



Photograph by Ernest Milner, Wandsworth, London, S.W.

Fig. 4. Basement in Course of Construction.

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walls and columns are taken down about 11 ft. 6 in. below the basement to the layer of gravel previously mentioned.

The general disposition and lay-out of the beams and columns is shown in the plan in *Fig.* 5, which is a typical floor plan, the reinforced members being indicated by the thick black lines.

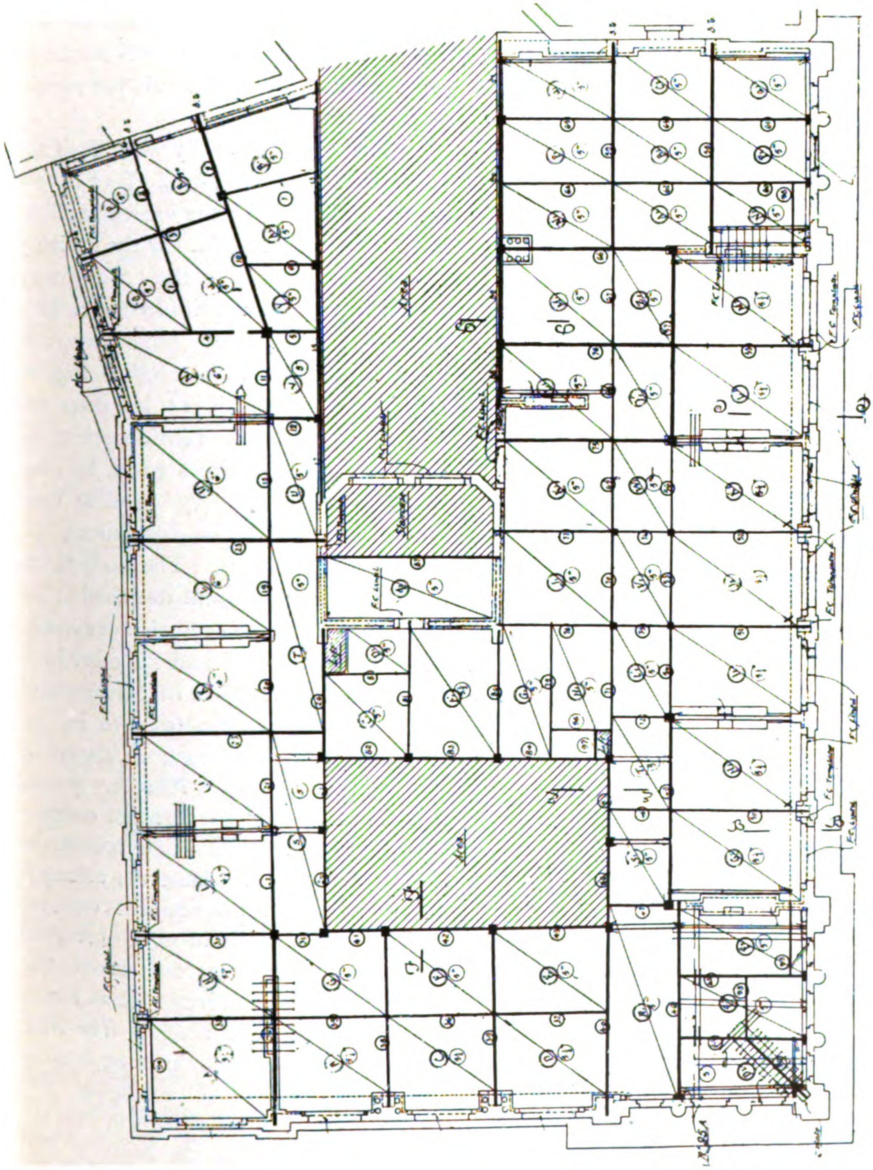

Fig. 5. Plan showing the Lay-out of the Beams and Columns with Reinforcement.
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The columns are all designed on the Hennebique system, and the largest of these in the basement is about 28 in. square.

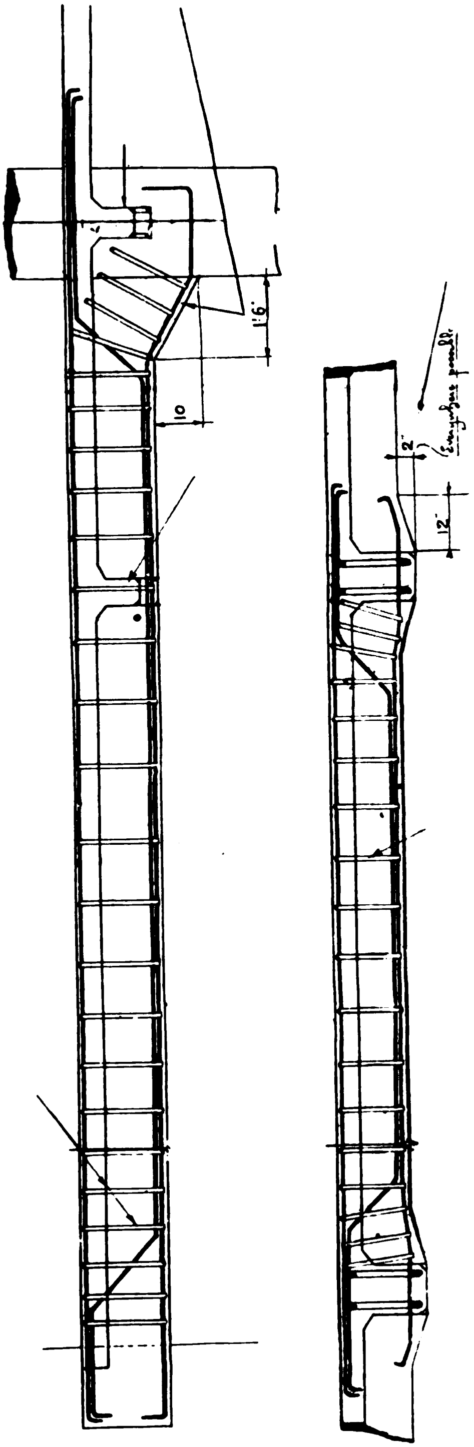

Fig. 6. Typical Beam Details.

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The floors generally have been designed to carry an external load of 112 lb. per ft. super, but in some instances the intended use of the rooms is such that exceptional loads have to be carried, and in these cases the floors were each designed to suit the special requirements.

The roofs generally were designed to carry an external load of 50 lb. per sq. ft. The floor slabs varied in thickness from 5 in. to 6 in. for the ordinary cases, and, except in the case of very small bays, were reinforced in both directions. Typical secondary and main beams are illustrated in *Fig.* 6, where the former is 15 in. deep and 6 in. wide, with reinforcement as indicated, and brackets 12 in. by 2 in. were formed in every possible case where the beam is continuous, as shown in the detail. The main beam here illustrated is 19 in. deep and 11 in. wide, and it will be seen that one end is supported on a wall and the other by a column. In all cases of beams abutting on columns brackets 10 in. by 1 ft. 6 in. were formed as shown in this typical detail. Another typical detail illustrating the bracket connections between beams and column is shown in *Fig.* 1, where the arrangement of the reinforcement can be clearly seen. Reinforced concrete templates were provided under the ends of several reinforced beams where they rested on the walls. The roof work contains some interesting details, and the method of arranging the sloping beams is illustrated in *Fig.* 7. It will be seen that the depth of the beam forming the abutment at the foot is slightly increased to take the thrust, and additional reinforcement is provided.

The shuttering and reinforcement

in position for a portion of this roof work is shown in the photographic view illustrated in *Fig.* 8. The concrete throughout was machine mixed, and two electric hoists were installed for raising the mixed concrete to the different levels.

Although there are no exceptional constructional features in this building, it affords a typical example of the application of reinforced concrete, and further illustrates the extensive use of this material in Government buildings; and this should have great influence with private building owners, a great number of whom are so conservative that they are still dubious as to the efficiency of reinforced concrete, and consequently do not avail themselves of the saving that can be made on the initial cost of their buildings by the use of this material.

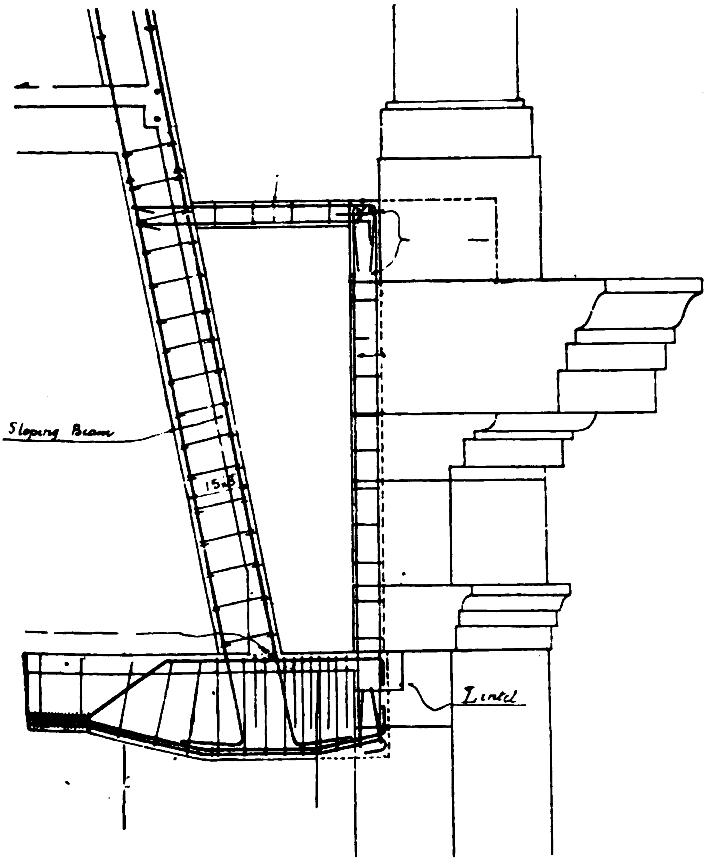

Fig. 7. Typical Detail showing Arrangement of Roof Beam.
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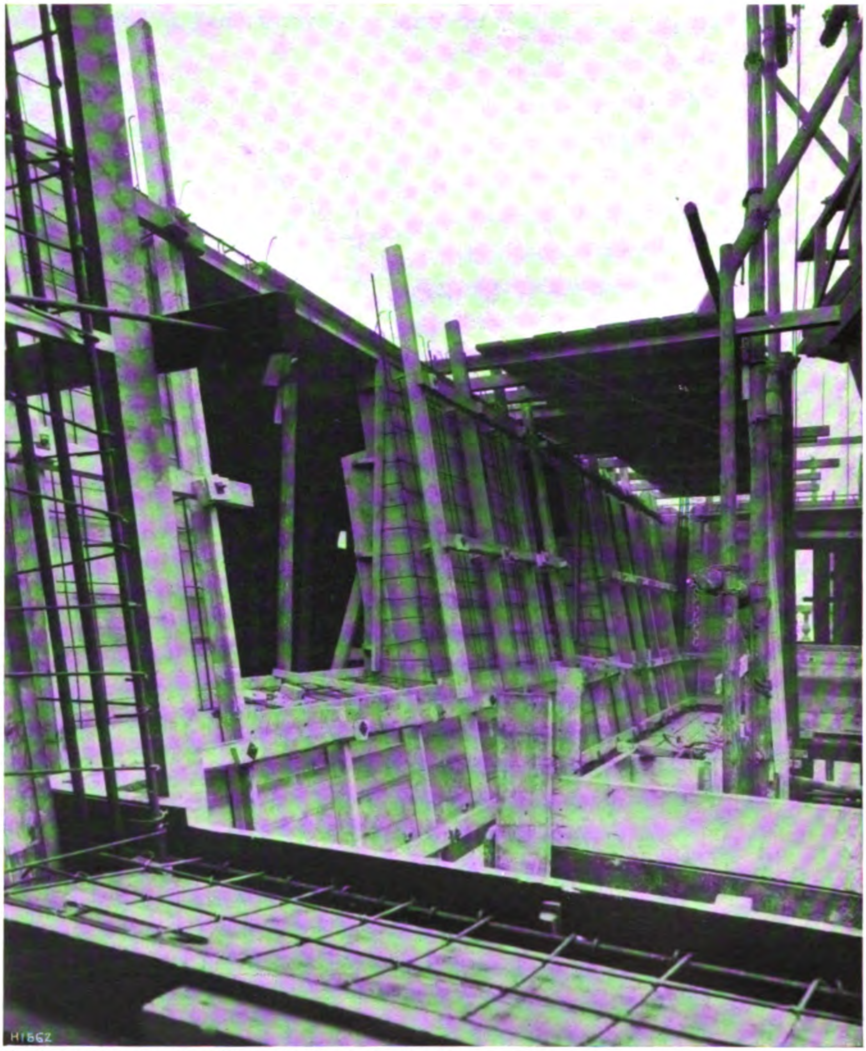
The foundations were constructed by Messrs. Holloway Bros. (London), Ltd., of Belvedere Road, S.W., under a separate contract, and the work of the superstructure is being executed by Messrs. Higgs and Hill, Ltd., of South Lambeth Road, S.W. The aggregate and sand for the concrete were supplied by the

Ham River Grit Co., of Ham and Wouldham, and the steel for the reinforcement by the Whitehead Iron and Steel Co., Ltd., of Tredegar. The concrete mixer was a Ransome pattern electrically driven mixer, and the cement was supplied by the British Portland Cement Co., Ltd.



Photograph by Ernest Milner, Wandsworth, London, S.W.

Fig. 8. View showing Reinforced Concrete Roof Slabs.

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WHAT IS THE BEST RATIO OF STEEL TO CONCRETE IN REINFORCED CONCRETE BEAMS & SLABS FROM £ s. d. POINT OF VIEW?

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As the question of economy in construction is one that is of considerable interest to all studying and dealing with reinforced concrete work, the following article may prove useful and of assistance to our readers.—ED.

In the present article equations are given to prove that, in all reinforced concrete structures designed to resist tensile stresses, there is only one ratio of reinforcement which conduces to the lowest cost in construction. This will, of course, depend upon the market values of steel and concrete, remembering that steel is by far the more costly material.

The cost of labour and material will differ in various localities; thus it is evident that the minimum cost of construction may be obtained by the use of varying ratios of steel according to the prices in the district. The ratio of steel that gives this maximum economy in the total cost of structure is *quite different* from the ratio of steel to concrete which develops the fullest stresses of steel and concrete. This latter ratio is often termed wrongly the "economic ratio," which is a most misleading term, for designers may easily misinterpret it to understand it as that ratio which gives the minimum cost.

Although it may appear too previous at this stage to ask the reader to glance at Chart No. 3 before going into further details, still it will arouse his interest, for that chart represents the varying costs of a set of reinforced concrete slabs with reinforcement varying from nil upwards. The sharp sudden turn at the bottom of the curve will bring home the fact at once, how the total cost rapidly rises for any other ratios of steel to concrete but for one particular ratio.

The charts accompanying this article give a rapid method of finding that particular and critical value of reinforcement ratio which conduces to the lowest cost. By the aid of these diagrams the required values of critical depth (of beam or slab), reinforcement, etc., can be determined accurately, when the bending moment on the structure is known.

Although the mathematical working out of the deduced equations is somewhat complicated, application of the final results and the reading of the charts for designing and checking purposes will be found to be extremely simple.

Let s denote the price of steel per lb. in pence, q denote the price of concrete per cu. in. in pence, and G the price of centering per sq. in. in pence.

All these figures should include the cost of labour, fixing, etc., on the site. These values are generally in pounds or shillings per cu. ft. or sq. yd.; but they can be easily converted. Further, the money unit need not be necessarily in pence; it may be in shillings, dollars or any unit, but it must be the same unit for s, q and G.

The basis upon which the calculations are made is the theory set forward in the Report of the Joint Committee (Royal Institution of British Architects) on Reinforced Concrete. The same nomenclature is here used, thus:—

b denotes the width in inches.

d denotes the effective depth in inches.

m denotes the $\frac{Es}{Ec}$ the ratio of the moduli of elasticity of steel and concrete (which is generally taken as 15).

M denotes the Bending Moment at the section considered in in.-lb. units.

t denotes the tensile stress in metal per sq. in.

c denotes the compressive stress in concrete per sq. in.

z denotes the distance of resultant thrust in concrete from compressed surface of beam in inches.

kd denotes the distance of neutral axis from compressed surface in inches.

$Ac=kbd$ denotes area of concrete in compression in sq. ins.

At denotes the area of metal in tension in sq. ins.

$p=\frac{At}{bd}$, the ratio of section of metal to section of concrete, *i.e.*, the ratio of reinforcement.

$P=100\,p$ or the percentage of reinforcement.

l denotes the span in inches.

w denotes the load per in. run of span.

W denotes the load in lb. per sq. in.

On page 521 of the foregoing Report, when dealing with beams of rectangular section with single reinforcement, it is stated that—"In a homogeneous beam the stresses are proportional to the distances from the neutral axis. In a discrete beam, such as a beam of concrete and steel, on account of the greater rigidity of steel, at a given distance from the neutral axis, the stress in the steel will be m times as great as in concrete." The formula for the position of the neutral axis s is then worked out to—

$$k=\sqrt{(p^2m^2+2\,pm)}-pm$$

that is, the neutral axis is lower as the amount of reinforcement is greater, and passes the half depth for 2 per cent. The distance of the resultant thrust from the compressed surface is $z=\frac{1}{3}kd$, and bending moment equation becomes—

$$\begin{aligned}M&=\tfrac{1}{2}\,A_cc\,(d-\tfrac{1}{3}\,kd)\\&=\tfrac{1}{2}\,kbd^2c\,(1-\tfrac{1}{3}\,k)\end{aligned}$$

It will be noted, therefore, that the strength of a rectangular beam of reinforced concrete can be put directly into the form $M=Cbd^2$, where C has a value which depends upon the ratio of reinforcement adopted in the design, taking of course, into consideration the maximum stresses allowed, *i.e.*, in concrete and steel. In ordinary design, the usual practice appears to be 600 lb. per sq. in. for concrete in compression, and 17,000 lb. per sq. in. for steel in tension.

For the sake of convenience with regard to further calculations, a simple equation is needed connecting C and p directly. The equation which the author has himself deduced, $C=\frac{162P}{P+\cdot5}$ (where P stands for the percentage of reinforcement) satisfies the conditions and differs at most by 1 or 1·5 per cent. from the accurate values obtained by working out the foregoing equations for C and K, and K and p.

Allowing one inch of concrete as fire protection below the beam or slab, the volume of concrete used for this purpose would be lb cu. ins., therefore the total volume of concrete used would be $(lbd+lb)$ cu. ins.

$$\text{Volume of steel used}=\frac{P}{100}\,lbd$$

Let f = weight of steel per cu. in., then the weight of steel used $=\frac{flbdP}{100}$ lb.

The necessary amount of shuttering or centering required for the structure will be $l\ [2d+b]$, and the total cost of the structure, whether it be a beam or a slab, will be

$$lbdq + lbq + \frac{flbdP}{100}\,s + Gl\,(2d + b) \text{ units} \qquad (1)$$

The total bending moment on a beam or a slab will be equal to that due to the imposed loading plus the bending moment induced by its own weight. Taking the weight of reinforced concrete as 150 lb. per cu. ft., the weight of the beam or slab will be equal to $\cdot0865lbd$ lb. If therefore, W is the load per sq. in., the total bending moment becomes—

$$M = \frac{Wlb \times l}{\psi} + \frac{0{\cdot}0865lbd \times l}{\psi} \text{ in. lb.}$$

Where ψ may be equal to 8, 12, etc., according as to whether the beam is freely or rigidly supported.

Let $\frac{Wl^2}{\psi}$ be denoted by a and $\frac{0{\cdot}0865l^2}{\psi}$ by β.

It has been seen (page 86) that

$$M = Cbd^2$$

$$\therefore Cbd^2 = ab + \beta db$$

and by the ordinary solution for quadratic equations—

$$d = \frac{\beta}{2C} + \sqrt{\frac{a}{C} + \frac{\beta^2}{4C^2}}$$

If an actual example is worked out, it will be found that the term $\frac{\beta^2}{4C^2}$ becomes negligible, hence

$$d = \frac{\beta}{2C} + \sqrt{\frac{a}{C}} = \frac{\beta + 2\sqrt{aC}}{2C} \qquad (2)$$

It has been shown that a direct relationship between C and P may be put in the form $C = \frac{NP}{P+m}$ where $N = 162$ and $m = \cdot5$, therefore $P = \frac{mC}{N-C}$.

Substituting these values for d and P in equation (1) the following value is obtained:

Total cost $= lbq$

$$\left[\frac{\beta + 2\sqrt{aC}}{2C}\right] + lbq + \frac{mflbs}{200}\left[\frac{\beta + 2\sqrt{aC}}{N-C}\right] + Gl\left[\frac{\beta + 2\sqrt{aC}}{C} + b\right] \qquad (3)$$

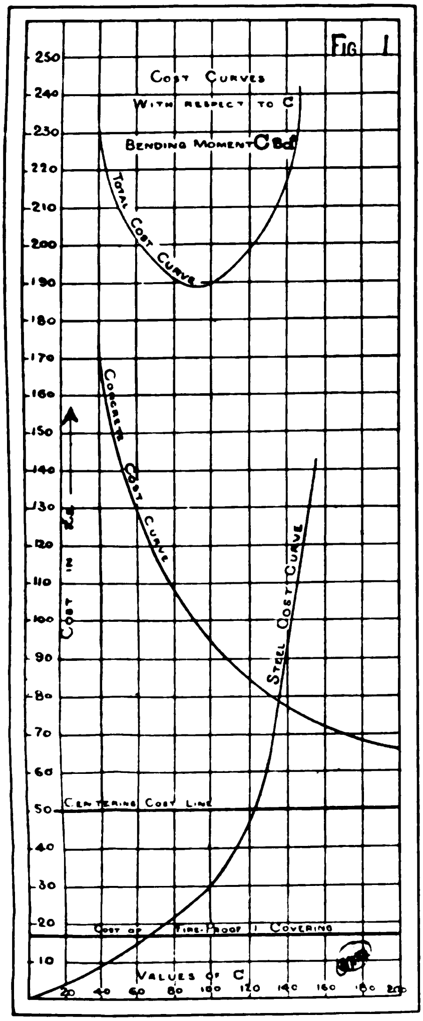


Fig 1 Vertical Scale 1 Centimetre £10

Horizontal Scale 1 Centimetre = 20 Units

Data 40 slabs 10'x10' Load 288 lbs/□' i.e. 2 lbs/□"
BM = $\frac{WL}{12}$ s = one pence per lb, q = one shilling per cubic foot
G = 27 pence per sq yard Fireproof Protection One inch thick

The total cost could have been put as a function of d, but by making it a function of C matters are much simplified. To find out at what value of C the total cost is a minimum, it is necessary to differentiate equation (3) with respect to C, but it can be shown graphically that there is a minimum by plotting the curves as shown in *Fig. 1.*

Representing total cost by the symbol T_c and differentiating with respect to C

$$D(T_c)=lbq\left[-\frac{\beta+\sqrt{\alpha C}}{2C^2}\right]$$

$$+\frac{mflbs}{200}\left[\frac{N\sqrt{\alpha}+\sqrt{C}(\beta+\sqrt{\alpha C})}{\sqrt{C}(N-C)^2}\right]+Gl\left[-\frac{\beta+\sqrt{\alpha C}}{C^2}\right] \tag{4}$$

To determine that value of C which will make T_c a minimum, it is necessary to equate equation (4) to zero and solve for C. If $\frac{s}{q}$ *i.e.* $\frac{\text{cost of steel per lb.}}{\text{cost of concrete per cu. ft.}}$ be denoted by symbol R, and $\frac{2G}{qb}$ be denoted by γ, this minimum value is given by

$$-\frac{\beta+\sqrt{\alpha C}}{C^2}+\frac{mfR}{100}\left[\frac{N\sqrt{\alpha}+\sqrt{C}\ (\beta+\sqrt{\alpha C})}{\sqrt{C}\ [N-C]^2}\right]+\gamma\left[-\frac{\beta+\sqrt{\alpha C}}{C^2}\right]=0 \tag{5}$$

$$-\frac{\beta+\sqrt{\alpha C}}{C^2}(1+\gamma)+\frac{mfR}{100}\left[\frac{N\sqrt{\alpha}+\sqrt{C}\ (\beta+\sqrt{\alpha C})}{\sqrt{C}(N-C)^2}\right]=0 \tag{6}$$

The above equation is fairly complicated owing to the presence of β. Now from various examples it has been found that by neglecting β in the above equation, it reduces the deduced value of C by very nearly 4 per cent. Hence to avoid unnecessary complexity it is better to neglect β temporarily and then adjust the equation afterwards It has been stated before that $\beta = \frac{\cdot 0865 l^2}{\psi}$ and is also equal to $\left[\frac{\cdot 0865}{W}\right]\alpha$.

Temporarily neglecting β equation (6) becomes

$$-\frac{1}{C}+\frac{mf}{100}\frac{R}{(1+\gamma)}\left(\frac{N+C}{(N-C)^2}\right)=0 \tag{7}$$

Let $\frac{100}{mf}=n$ and $\frac{R}{1+\gamma}=R_1$

Solving the quadratic for C

$$C=\frac{2Nn}{(\sqrt{R_1^2+8R_1n}+R_1+2n)} \tag{8}$$

This equation shows that the value of C and hence the ratio of Reinforcement which makes Tc a minimum is dependent upon the ratio of s to q—*i.e.*, the price of steel to concrete.

It can be shown that the error involved in evolving the value P by neglecting R_1^2 (under the square root sign) is so small, as compared to the exact value from equation (8) as it stands, that for practical purposes it is justifiable to neglect R_1^2 which reduces equation (8) to a simple formula.

Further β has been temporarily neglected. To adjust for its loss, equation (8) should be multiplied by 1·04. This increases the value of C to the necessary amount.

Thus neglecting R_1^2

$$C=\frac{2Nn\times 1{\cdot}04}{[2\sqrt{2R_1n}+R_1+2n]}$$

$$\text{or } C=\frac{2Nn\times 1{\cdot}04}{(\sqrt{R_1}+\sqrt{2n})^2} \tag{9}$$

Substituting in the above equation the values of R_1 and n

$$C=\frac{200N\times 1{\cdot}04}{mf\left[\sqrt{\frac{R}{1+\gamma}}+\sqrt{\frac{200}{mf}}\right]} \tag{10}$$

This is the general equation of the economic C in terms of symbols. Giving the constants N, m and f their respective values 165, ·5 and ·29 (assuming that steel weighs 490 lb. per cube ft.)

$$C=\frac{232900}{\left[\sqrt{\frac{R}{1+\gamma}}+37{\cdot}1\right]^2} \qquad (11)$$

$$\text{where } \gamma=\frac{2G}{qb}\cdot$$

This equation applies to both beams and slabs. In the case of slabs b is a very arge quantity, as compared to the depth, and the expression $\frac{2G}{qb}$ becomes exceedingly small compared even to unity, and could be neglected; therefore for slabs, formula given by equation (11) can be still further simplified by dropping out γ and the expression becomes

$$C=\frac{232900}{(\sqrt{R}+37{\cdot}1)^2} \qquad (12)$$

This equation can be put in any convenient form; thus if s were price of steel per lb. and Q price of concrete per cub. ft., then calling $S/Q=J$, R in the above equation is equal to $12^3\times J$, and by substitution another formula can be evolved of the form

$$C=\left[\frac{A}{\sqrt{R}+B}\right]^2 \qquad (13)$$

The truth of the above equations for C can be conclusively proved by working out arithmetically an actual example and by plotting various values of total cost with corresponding values of C, to show that there does exist a minimum value of total cost.

EXAMPLE I.

To take an actual example such as the following case of floor panels in a large building, let s, price of steel = 1d. per lb., price of concrete = 1s. per cube ft., and price of centering = 27d. per sq. yd. For slabs, there will be little or no centering required along its depth, the chase in the walls acting same. In this case only the centering for the superficial area will be considered.

$$\text{Total cost}=lbq\left(\frac{\beta+2\sqrt{\alpha C}}{2C}\right)+lbq+\frac{{\cdot}29\text{ lb.}}{200}\times\frac{{\cdot}5\,[\beta+2\sqrt{\alpha C}]}{[162-C]}+Gl[0+b],$$

$w=288$ lb. per sq. ft. $=2$ lb. per sq. in.

$l=120$ in.

$b=120$ in., and number of panels in the building be equal to 40.

Taking $\psi=12$ $\quad \alpha=\frac{Wl^2}{\psi}=2400.$

$\beta+2\sqrt{\alpha C}=100(1+\sqrt{C})$ very nearly.

Cost of concrete for 40 panels in £s.

$$=\frac{120\times120\times100(1+\sqrt{C})}{144\times2\times C}\times\frac{40}{240}$$

$$=£833\left[\frac{1+\sqrt{C}}{C}\right].$$

Cost of steel for 40 panels in £s.

$$=\frac{{\cdot}29\times120\times120\times{\cdot}5\times100\,(1+\sqrt{C})}{200\times12\times(162-C)}\times\frac{40}{20}$$

$$=£\text{s }174\left(\frac{1+\sqrt{C}}{162-C}\right)$$

Fireproof one-inch concrete covering cost = £s 16·666. Cost of centering for 40 panels @ 27d. per sq. yd. = £50·000. The total costs corresponding with various values of C have been plotted in *Fig.* 1, and are also given in the following table :—

Percentage of Reinforcement.	0	0·224	0·625	0·69	0·73	0·81	1·04	4·0	∞
C	0	50	90	94	96	100	110	144	162
$\sqrt{C}$	0	7·071	9·487	9·695	9·79	10·0	10·5	12·0	12·72
$1+\sqrt{C}$	1	8·071	10·487	10·695	10·79	11·0	11·5	13·0	13·72
$\frac{1+\sqrt{C}}{C}$	∞	0·161	0·117	0·114	0·112	0·110	0·105	0·090	0·085
$162-C$	162	112	72	68	66	62	52	18	0
	£	£	£	£	£	£	£	£	£
$833\left(\frac{1+\sqrt{C}}{C}\right)$	∞	134	97·46	95·0	93·5	91·63	87·5	75·0	71·0
$174\left(\frac{1+\sqrt{C}}{162-C}\right)$	1·04	12·53	25·23	27·14	28·53	30·97	38·45	125·63	∞
Centering Cost	50·0	50·0	50·0	50·0	50·0	50·0	50·0	50·0	50·0
Fireproof Cost	16·66	16·66	16·66	16·65	16·66	16·66	16·66	16·66	16·66
Total Cost......	∞	213·19	189·35	188·8	188·69	189·26	192·61	267·29	∞

Fig. 1 shows that the Tc has a minimum value somewhere between $C=94$ and $C=96$.

Instead of laboriously working out this table every time, the economic C can be very quickly worked out from equation (12).

$R=\frac{s}{q}=144$ in this particular example, substituting this value for R in equation

$$C = \frac{232900}{(\sqrt{R}+37{\cdot}1)^2}$$

$$C = 96 \text{ (by slide rule)}$$

and
$$P = \frac{{\cdot}5C}{162-C} = {\cdot}72$$

This value of C agrees very closely to that given by plotting *Fig.* 1.

EXAMPLE II.

Taking the same values for steel and concrete as given in Example I., and assuming that price of centering per sq. yd. is 27d., to find the economic C for a beam whose breadth is 12 in. In this case

$$C = \frac{232900}{\left(\sqrt{\frac{R}{1+\gamma}}+37{\cdot}1\right)^2}$$

$$R=144 \qquad \gamma = 2\left[\frac{27}{9\times 144}\right]\times\frac{144}{12}={\cdot}5$$

$$\sqrt{\frac{R}{1+\gamma}}=9{\cdot}798$$

$$C = 108\text{; therefore } P=1{\cdot}0.$$

By using the proper value of C the most economical designs can be produced, and a considerable amount of money can be saved. Undoubtedly cases may arise where the designer will have to choose other values of C for the sake of gaining advantages in some other direction, such as head-room, floor cut through by openings, etc., but in the author's experience he has found that the use of this formula saves much time in the office and yields very satisfactory results in practice.

Fig 2.

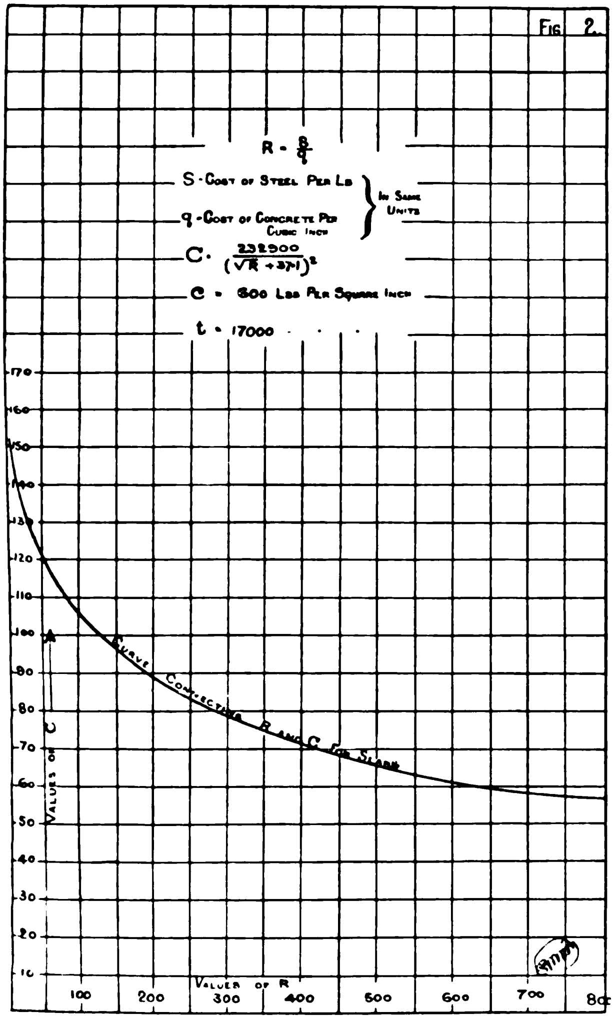


Fig 2 Vertical Scale 1 Centimetre = 10 Units

Horizontal Scale 1 Centimetre = 50 Units

This value of C to give a minimum cost can be obtained from a curve connecting R and C (*Fig.* 2), and knowing C, the value of P—*i.e.* the percentage of reinforcement—can at once be obtained from the equation

$$P = \frac{\cdot 5C}{162 - C}$$

or by referring to the chart given on page 536, "R.I.B.A. Report on Reinforced Concrete, No. I.," or the curve given in *Fig.* 4.

A General Review.

An examination of the cost curve (*Fig.* 1) will show that the total cost rises much more rapidly for values above the critical value of C than for values below it, and this unduly increases the cost of steel.

A stress of 600 pounds per square inch has been assumed as the working value for the stress (compression) in concrete, but if another value be chosen, say 750 pounds per square inch, an equation connecting C and P would be obtained of the same form as before, but with slightly different, values for the constants as follows:—

$$C = \frac{c}{2} K \left(1 - \tfrac{1}{3} K\right) = \frac{162P}{(P + \cdot 5)} = \frac{NP}{P + m}$$

where c=compressive stress (working in concrete per square inch).

K=ratio of the distance of the neutral axis from compressed surface to the total effective depth d.

c has been taken as equal to 600 lbs. per square inch, therefore

$$K\left[1 - \tfrac{1}{3} K\right] = \frac{0{\cdot}54P}{P + \cdot 5} \qquad (14)$$

Changing the value of c for a higher value of 750 lb. per square inch in compression.

$$C = \frac{c}{2} K (1 - K/3) = \frac{750}{2} \times \frac{\cdot 54P}{P + \cdot 5} = \frac{202{\cdot}5P}{(P + \cdot 5)} \qquad (15)$$

c

Similar changes will require to be made in the value of N in equation (10).

If wrought iron were used instead of steel, f which stands for the weight of material per cubic inch will have a different value in equation (10).

A few words should be said with regard to the deduction of equation $C=\frac{162P}{P+\cdot 5}$ which has been used throughout for deducing various equations. This equation traces the relationship between C and P, so that the compressive value for C, that is 600 lbs. per square inch, may not be exceeded. The exact fundamental equations indirectly connecting C and P are $C=\frac{c}{2}K(1-\frac{1}{3}K)$ and $K=\sqrt{(p^2m^2+2pm)}-pm$, remembering that P is the percentage of reinforcement, while p is the ratio of reinforcement, *i.e.* $p=\frac{P}{100}$.

If these fundamental equations were to be used in the total cost equation for deducing the economic C by differentiating, the mathematical working out and the results will be so complex as to be of little or no use in actual practice.

While admitting that a certain amount of approximating has been done, it must be remembered that it has been done with great care, so that the final result is not affected.

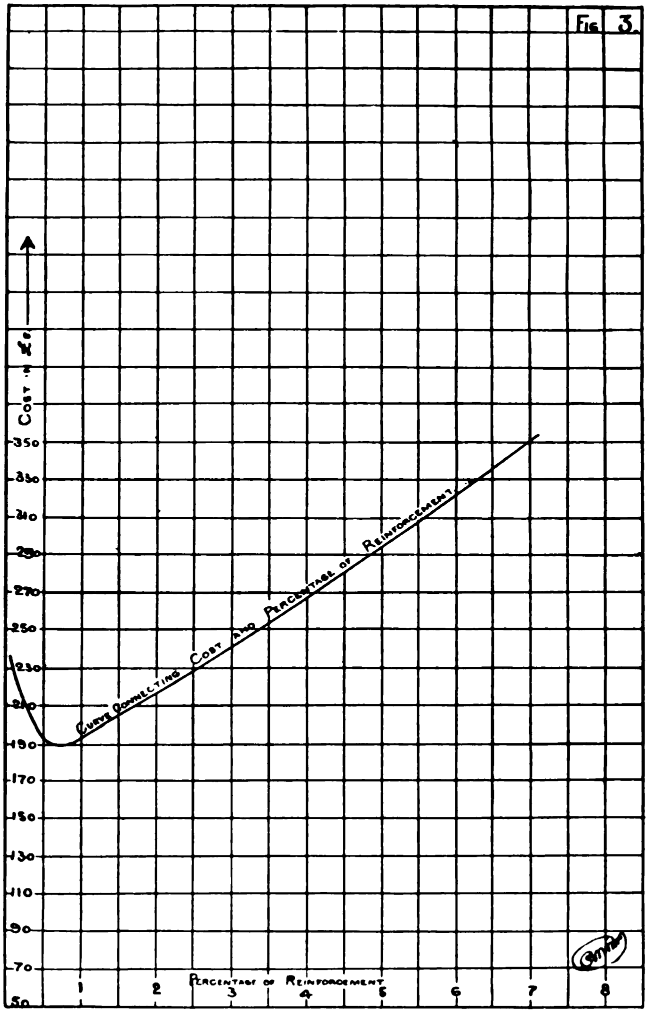


Fig. 3 Vertical Scale 1 Centimetre = £ 20

Horizontal Scale 1 Centimetre = ·5 Units

This curve is based on the same data as in Fig I

The equation of the total cost can be represented in terms of the depth of the slab or the beam. Probably it is easier to do so than to represent it in terms of C, but while differentiating to find the solution of the most economic d, it was found that the problem became somewhat complex, and making the total cost a function of C helped to simplify the conditions.

In actual practice the value of d can be obtained directly from equation (2), *i.e.*, $d=\frac{B}{2C}+\sqrt{\frac{a}{C}}$ if the bending moment due to weight of concrete is to be considered, or $d=\sqrt{\frac{a}{C}}$ if this is neglected.

. . . .

Evolving the value of d in the foregoing example, to give the minimum total cost, $d=\frac{100}{2\times 96}+\sqrt{\frac{2400}{96}}=0{\cdot}521+5{\cdot}00=5{\cdot}521$ inches. It will be noticed that the increment in depth due to the bending moment of the weight of concrete is 0·521 inches, and it is very advisable to calculate the value of d, which includes this value.

When $C=96$ $P={\cdot}72$ from the equation, $P=\frac{{\cdot}5C}{162-C}$, and from the table on page 90 a curve can be drawn showing how the total cost varies with P (*Fig.* 3). This curve will show the percentage of reinforcement beyond which it is advisable not to go, except at the sacrifice of considerable expenditure. The curve gives the costs both at 1·7 per cent. of reinforcement and 0·25 per cent. as £210, the minimum cost being, as before, seen from the curve £188·6 at ·72 per cent.

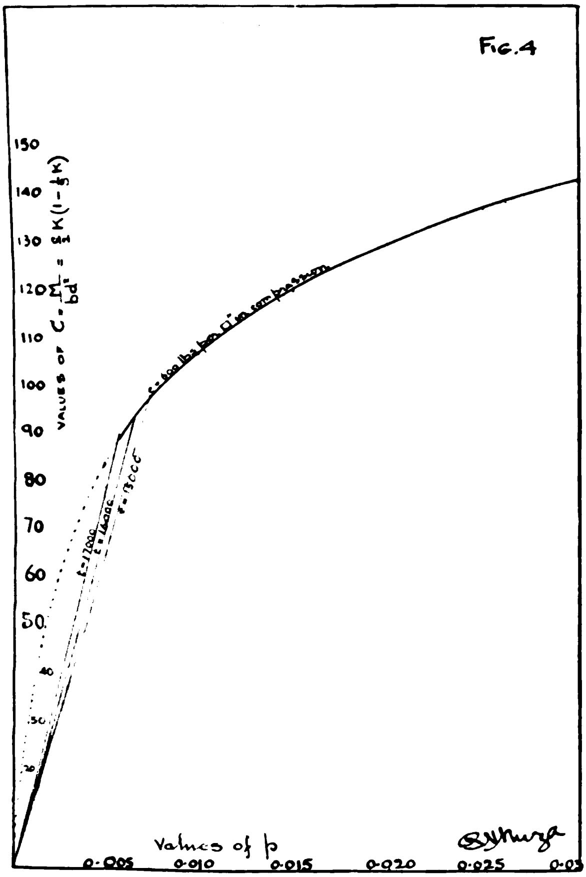


Fig.4

In conclusion it may be useful to summarise the various results here:—

(1.) There is only one value of the ratio of reinforcement which gives the total cost of reinforced concrete slabs as a minimum, and this total cost depends on the cost of steel and concrete, including labour, fixing, etc., on the actual site.

(2.) It is not always economical to develop the full stresses of steel and concrete, for although it may give a higher mechanical efficiency it may be at a considerable increase in cost, which is not always acceptable.

(3.) Similarly there is one definite ratio of reinforcement which gives the cost of reinforced concrete beams as a minimum cost. This value depends on the price of steel, concrete and centering, including labour, fixing, sawing, etc.

(4.) The value of economical ratio of reinforcement for beams is higher than that for slabs, on the assumption that in slabs very little centering or none is required for its depth, while in case of a beam, the centering required along its depth is an important item. If a special case of slabs arises which require considerable centering with reference to its depth, then such slabs should be treated as beams.

(5.) If a high price for steel has to be paid, it is better to buy the material having a high tensile strength, for if on a job the steel cost is likely to be 2½d. per lb. owing to the use of special bars, and concrete cost were to be 1s. per cube foot, then from equation (12) $C=74$, hence $p=\cdot0045$, which means that $K=\cdot31$, and from the fundamental equation $\frac{mc}{t}=\frac{K}{1-K}$ (and as C is 600 lb. per square inch for concrete in compression), t the tensile strength for steel per square inch will be 20,000.

(6.) Special cases may arise with reference to this subject, and many corresponding formulæ may be evolved with little effort from the primary equations. The main object of the mathematical investigation is to suggest a method by which other problems of the same nature may be tackled. For example, the fundamental equations assumed here are $\frac{mc}{t}=\frac{K}{1-K}$ and $1/2\ cbKd=pbdt$ (see No. 1 R.I.B.A. report, page 521), but some other authorities adopt the following, assuming that the stress strain curve of concrete is a parabola and not a straight line: $\frac{mc}{t}=\frac{K}{1-K}$ and $2/3\ cbKd=pb.dt$.

This means that in the first case $K=\sqrt{p^2m^2+2\ pm}-pm$, while in the latter case, $K=\cdot75\left[\sqrt{p^2m^2+2.66\ pm}-pm\right]$. This will naturally mean a slight alteration in the deduced equations $K\left[1-\frac{1}{3}K\right]=\frac{\cdot54P}{P+\cdot5}$ or $C=\frac{162\ P}{P+\cdot5}$ and finally in equations (11) and (12), but the difference will not be very serious.

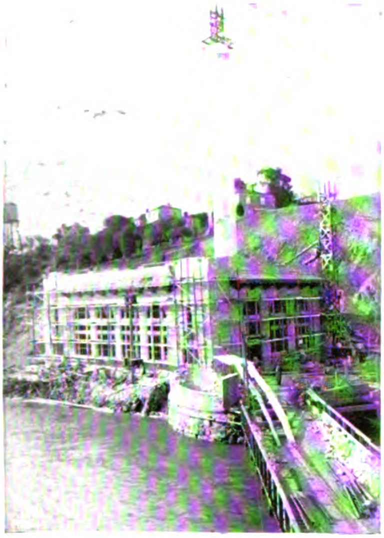


Fig. 1. Reinforced Concrete Pumping Station, San Francisco.

REINFORCED CONCRETE IN MUNICIPAL ENGINEERING WORKS IN SAN FRANCISCO, U.S.A.

By E. R. MATTHEWS, A.M.Inst.C.E., F.R.San.Inst.,
Borough Engineer of Bridlington.

Some interesting examples of municipal work in reinforced concrete have recently been carried out in San Francisco, and we are able to give a few particulars and illustrations of this work in the subjoined article.—ED.

THE use during the past few years of reinforced concrete in the municipal works which have been carried out by the City Authorities of San Francisco has been very extensive.

Sewers.—This material has been used with marked success in sewer construction, and in a previous issue of this journal a description and illustration of its use for this purpose in the construction of the Minposa outfall sewer were given.

Since that sewer was completed, the City Engineer of San Francisco, Mr. M. MacShaughnessy, has put in other sewers in this material, notably the Lincoln Way sewer (see *Fig.* 3), and the Division Street sewer outfall (see *Fig.* 2). The former is a reinforced concrete circular sewer with invert lined with brickwork; the latter consists of reinforced walls and floor and roof slabs forming three openings, through which the sewage passes.

The Kentucky Street sewer has also been constructed. This is an egg-shaped sewer (except that it has a flat top), and is 2 ft. 6 in. by 3 ft. 9 in. in size (see *Fig.* 4), and is a plain concrete sewer with brick invert and reinforced concrete slab roof.

Reservoir Construction.—The Twin Peaks reservoir, completed about eighteen months ago, is one of the finest examples of a reinforced concrete reservoir to be found. It is oval in plan, and is divided into two parts by a reinforced concrete dam, for which purpose the material used is admirable. *Fig.* 5 shows a portion of the floor of the reservoir, and is a good view of the reinforcement, showing precisely the arrangement of same. The completed reservoir as now being used is shown in *Fig.* 7. These photographs illustrate a very excellent

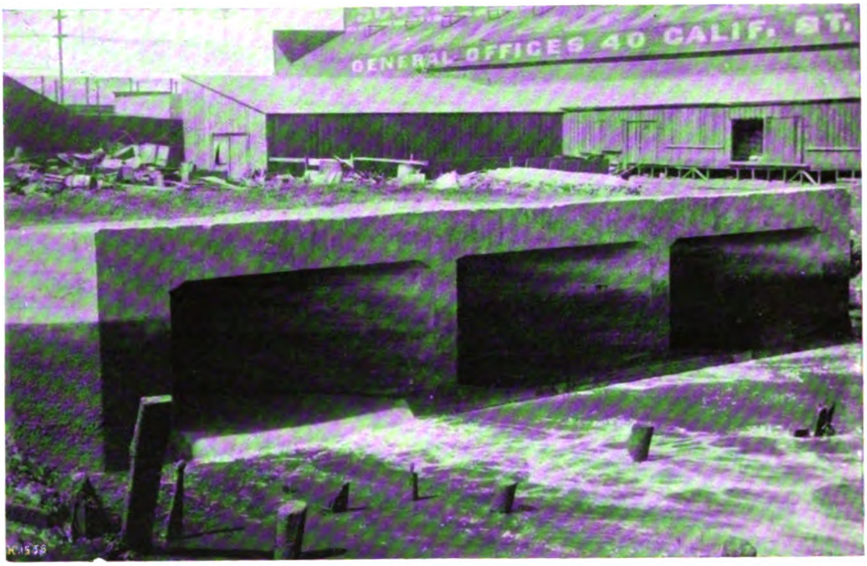


Fig. 2. View showing Sewer Outfall Construction.
REINFORCED CONCRETE SEWER, DIVISION STREET, SAN FRANCISCO.

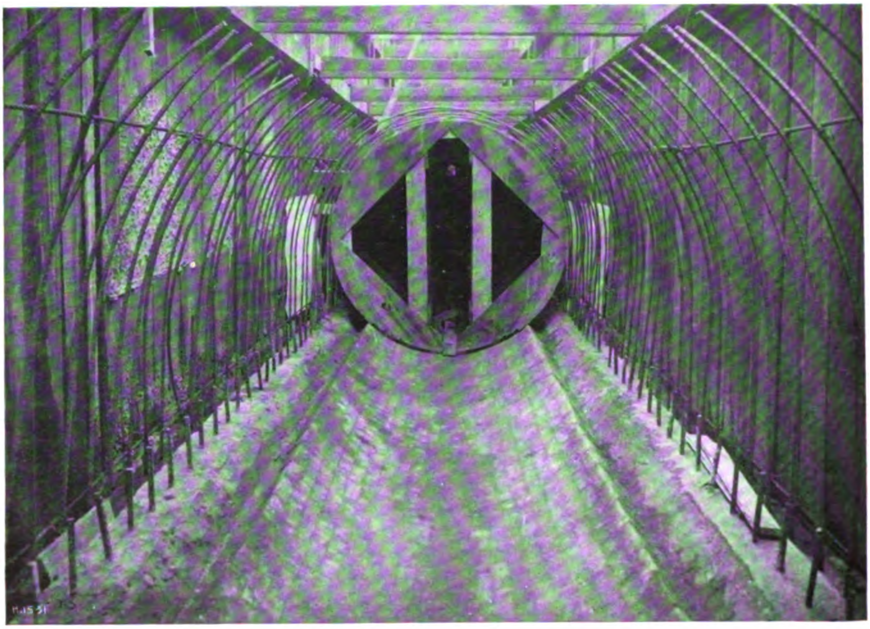


Fig. 3. Sewer Construction.
REINFORCED CONCRETE SEWER, LINCOLN WAY, SAN FRANCISCO.

piece of engineering work, which reflects great credit on the City Engineer, who designed the works and supervised their construction.

A few particulars regarding this interesting reservoir may be useful to those of your readers who are interested in waterworks engineering.

The reservoir is 750 ft. above the business section of San Francisco, and is part of the high pressure system for fire extinguishing purposes, established in consequence of the terrible fire of 1906. The reservoir is 370 ft. by 285 ft. in area, and allows for a depth of water of 27 ft., or a capacity of 11,000,000 gallons.

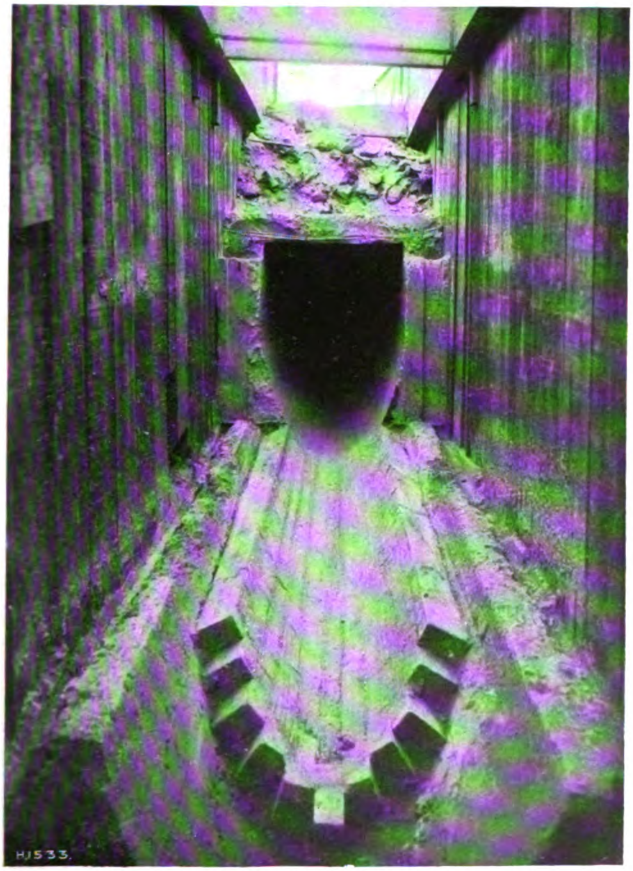


Fig. 4. View showing Sewer Construction.
REINFORCED CONCRETE SEWER, KENTUCKY STREET, SAN FRANCISCO.

One half of the reservoir may be filled while the other half is being cleaned or repaired, and the buttresses are spaced at 9 ft. centres, and are uniform on both sides of the division wall. They are 1 ft. in thickness and 13 ft. wide at the base.

On the completion of the work one half was filled to a depth of 25 ft. 6 in., the other being used as an auditorium in connection with the opening ceremony.

Before being filled, the reservoir was washed down with cement by means of a cement "gun"; this waterproofing operation took eight days, and the work was executed by the Pacific Cement Gun Co., of San Francisco.

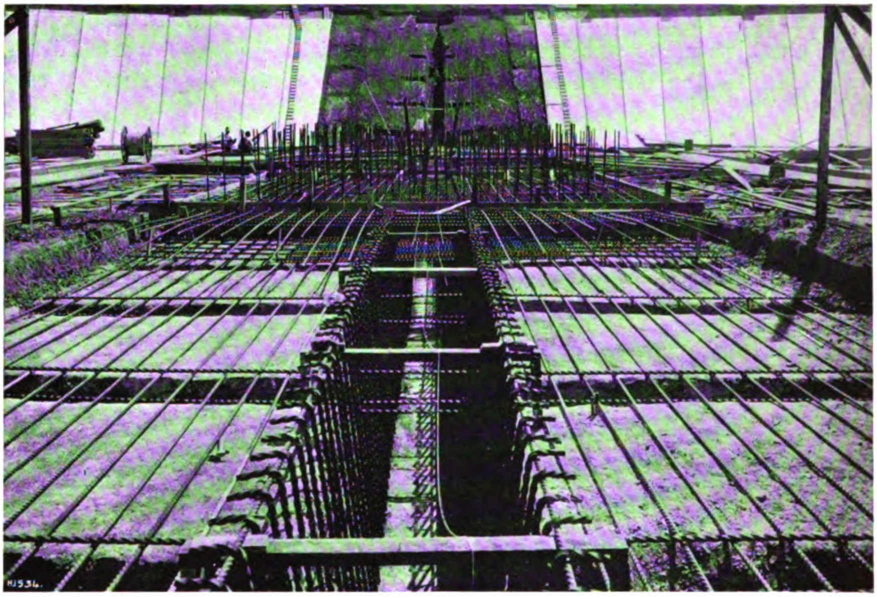


Fig. 5. View showing Reinforcement.
REINFORCED CONCRETE RESERVOIR, TWIN PEAKS RESERVOIR, SAN FRANCISCO.

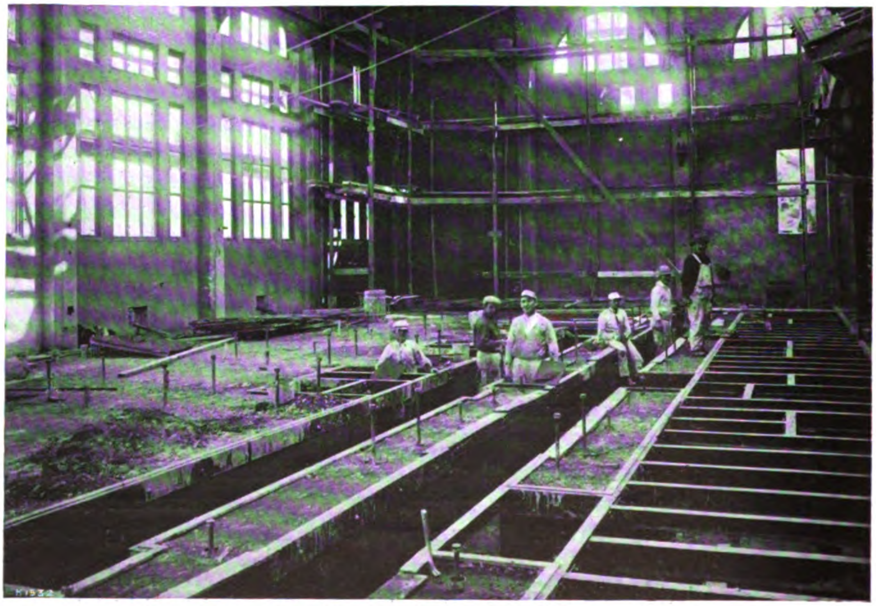


Fig. 6. View of Pumping Station in course of construction.
REINFORCED CONCRETE PUMPING STATION, SAN FRANCISCO.

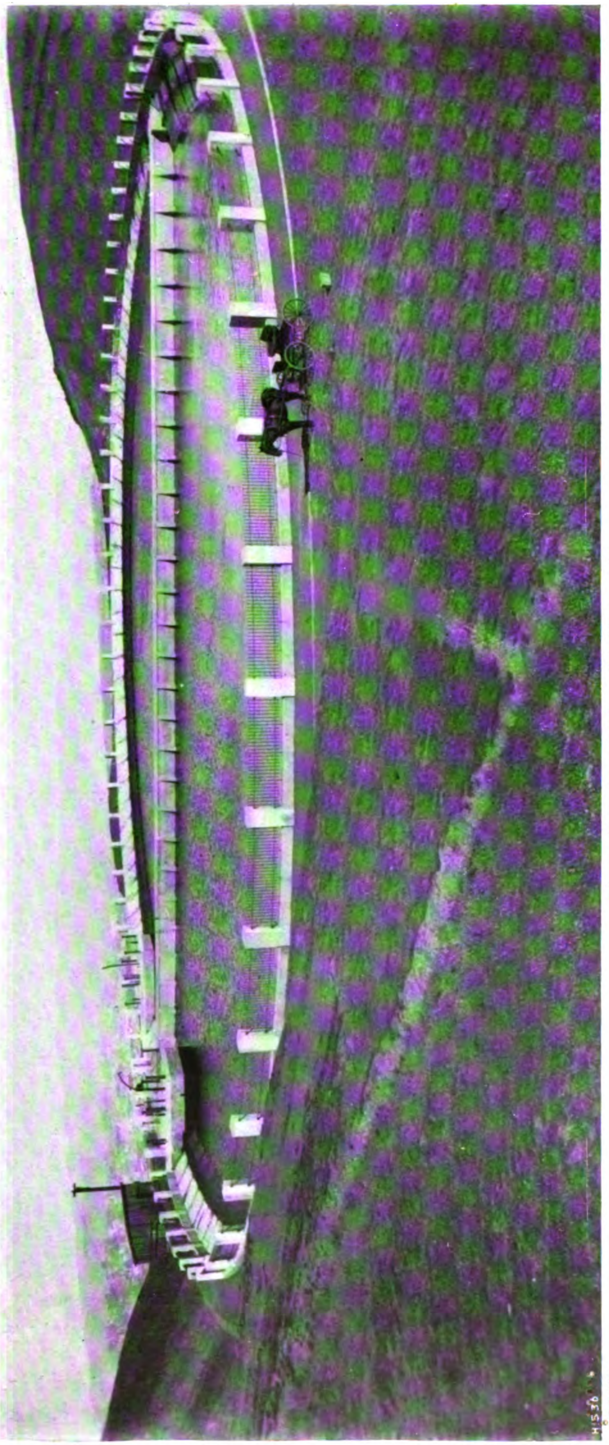


Fig. 7. View showing Completed Reservoir.

Reinforced Concrete Reservoir, Twin Peaks, San Francisco.

Pumping Station.—In addition to this important reinforced concrete work carried out during the past two or three years, a large pumping station has been erected in the same material; this is illustrated in *Figs.* 1, 6, 8, and 9, and represents some excellent architectural work. *Fig.* 6 shows the interior view of the machinery room in course of construction. *Fig.* 8 shows the

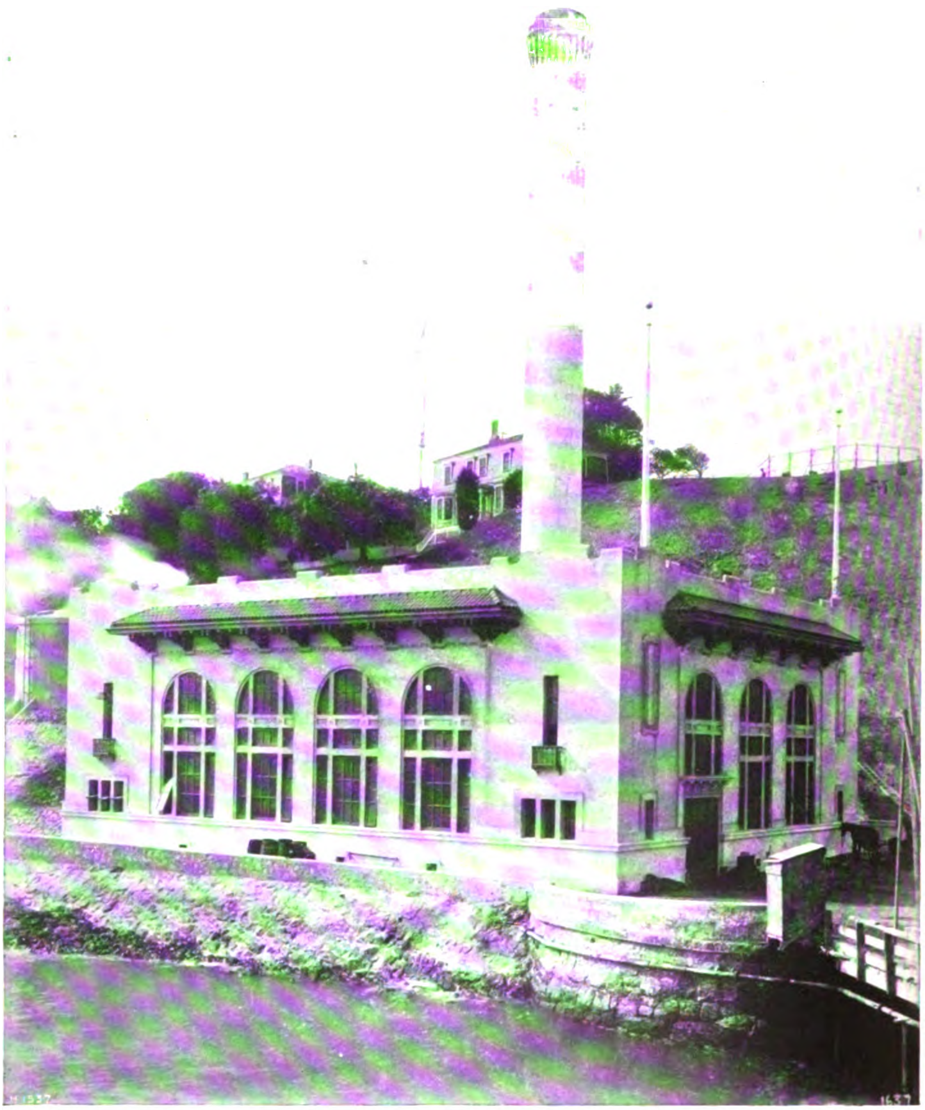


Fig. 8. View showing Finished Structure.

REINFORCED CONCRETE PUMPING STATION, SAN FRANCISCO.

completed structure, including the reinforced concrete chimney. *Figs.* 1 and 9 show the building in course of erection.

The author would, in conclusion, express his indebtedness to the City Engineer of San Francisco, Mr. MacShaughnessy, for his kindness in sending him the photographs of these important works and for giving him the privilege of reproducing them.

He would state that, in his opinion, reinforced concrete is the best material to use in reservoir and culvert construction in *this* country, as well as in countries subject to earthquake shocks.

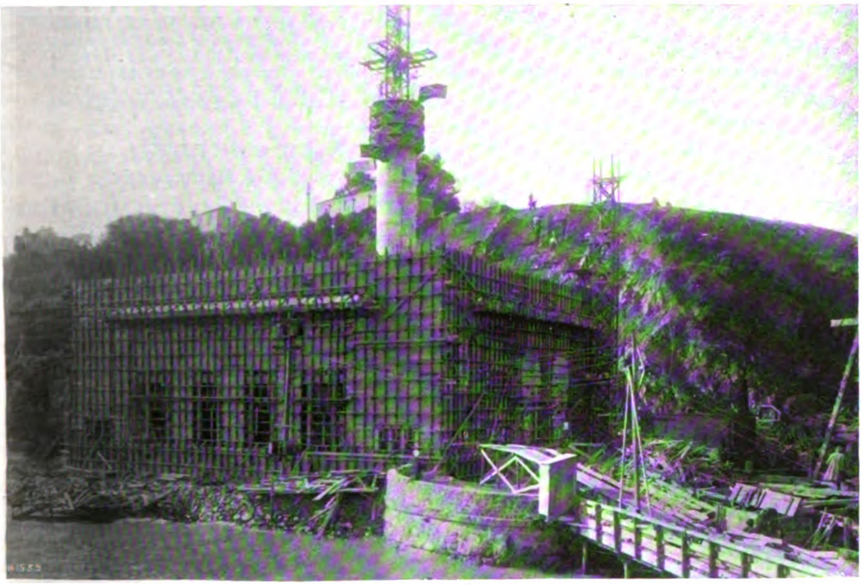
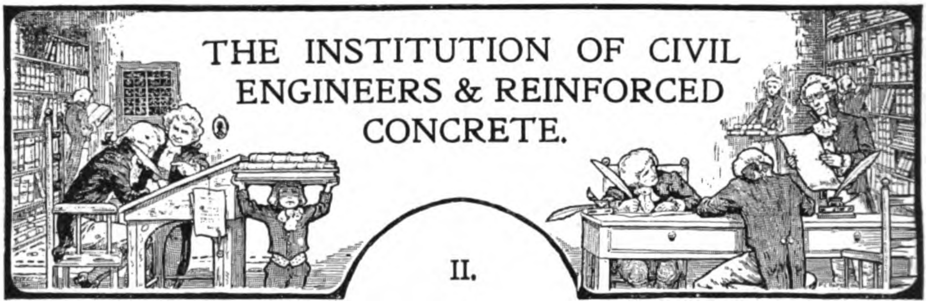


Fig. 9. Building in course of construction.
Reinforced Concrete Pumping Station, San Francisco.



THE INSTITUTION OF CIVIL ENGINEERS & REINFORCED CONCRETE.

II.

Second Report of the Committee on Reinforced Concrete.

In Volume V. of this Journal—October, November, December, 1910 (pp. 703, 707, 798 and 880)—we dealt very fully with the Interim Report of the Institution of Civil Engineers regarding Reinforced Concrete. The Second Report has now been issued, and although somewhat disappointing as a whole, such points as are of interest in the report and which call for attention are dealt with in this article, the first part of which appeared in our December issue. Owing to lack of space this article had to be omitted from our January issue.—ED.

CALCULATIONS FOR REINFORCED CONCRETE.

THE calculations for reinforced concrete are dealt with in Memorandum F, and the statement was prepared by Mr. F. E. Wentworth-Sheilds and Professor J. D. Cormack, D.Sc., and generally speaking we find that it is somewhat disappointing. The notes are incomplete and appear to be a repetition of portions of the Second Report of the Joint Committee of the Royal Institute of British Architects, whereas we should have looked for more originality in an Institution which refused to co-operate with other Societies, and certainly there is a lack of completeness and authority which is surprising when the status of the Institution is considered. The usual assumptions were made in deriving the formulæ, and these were as follows :—

(1) The stresses in both steel and concrete are proportional to the strains (straight-line theory). In other words, the moduli of elasticity are constant for both steel and concrete, and hence the ratio of the moduli is constant.

(2) A plane cross section remains plane after loading. In a piece subjected to bending this means that the strains in both concrete and steel are proportional to the distance from the neutral axis, and hence from assumption (1)—the stresses in both concrete and steel are proportional to the distance from the neutral axis.

(3) The tensile strength of the concrete is considered to be zero.

(4) The stress in a reinforcing bar of small section is considered as uniform over the whole section.

In addition, it is usual when designing to assume that :

(5) The initial stresses set up in concrete and steel owing to changes in volume of concrete while setting are zero.

(6) The stresses set up in concrete and steel owing to changes of temperature are zero, provided the whole piece is free to expand or contract.

The Committee appear to have taken a great deal of trouble in trying to prove that these assumptions are not strictly true in all cases, and yet they adopt them and have no suggestions or recommendations to offer which are the outcome of their findings. In dealing with the value of Es/Ec the statement is made that this varies from 10 to 15, but as a matter of fact it will be found to vary even more than this, and no mention is made of the influence of the reinforcement such as we find in the Report of the French Commission du Ciment Armé, where it is stated that it is preferable to regard the co-efficient as the result of experience on pieces with longitudinal and transverse reinforcement, and not as representing the ratios found from concrete and steel separately.

The results of tests on reinforced beams as observed are such that they agree with the position of the neutral axis as found by using the value of $Es/Ec = 15$, but there is a certain vagueness in the manner in which the notes of the Committee are presented that has the effect of leaving the reader rather uncertain as to what is really recommended. It is stated that the results obtained by assuming $m = 10$ are in most cases rather safer than if $m = 15$ is assumed, although the majority of countries make the latter assumption. We assume that the latter fact accounts for the Committee adopting a value which apparently does not quite coincide with their own deductions.

Following the assumptions that are adopted and the reasons for and against such assumptions, ten formulæ are given for beams and columns which are stated and obtained in the Second Report of the Joint Committee on Reinforced Concrete appointed by the Royal Institute of British Architects, and some notes are then given on deflection.

Despite the importance of the subject, we notice that no recommendations are made with reference to the values of the bending moments for fixed and continuous beams and slabs under different conditions of loading, and there is some difference of opinion on this question amongst engineers. It must be considered a great oversight on the part of the Committee, who appear to commence in the middle of the subject, and omit all consideration of those points which are the first to be dealt with in actual design. It appears to us that some useful work might have been accomplished in this direction, whereas the whole question has been entirely neglected.

The few general notes that are given in the calculations do not appear to be of much value, and the Second Report of the R.I.B.A. has been drawn upon to such an extent for the formulæ which are stated that very little credit can be given to the Committee of the Institution of Civil Engineers. Surely there is still a large field for investigation which is open to a committee of this kind, and assuming that they approve of the work already done by other Institutions, this could be endorsed, and attention devoted to the consideration of those matters which are at present in a more or less unsatisfactory state. There is the question of the frictional stress between concrete and steel which has not yet been sufficiently investigated, the bending moments for continuous beams, the design of column foundations, the question of eccentric loading on columns, and many other items which might with advantage be dealt with and investigated thoroughly, with a view to deducing some reliable information which would be of value to engineers.

Following the notes on the calculations are various tables giving in a brief manner the results of some experiments made in France, Germany, the United States, and Great Britain on columns reinforced in various ways, and comparing the calculated safe loads with the actual loads required to cause failure. These results indicate that the R.I.B.A. formula is quite satisfactory, and the notes attached and explanation of the tests and the results are interesting, and indicate the range of experiments, the manner of failure, and the effect of the longitudinal and lateral reinforcements. The experiments conducted in Great Britain include those carried out for H.M. Office of Works by Messrs. Kirkaldy in 1908-9, and described in our issue for March, 1910, and those carried out by Mr. W. C. Popplewell at Manchester, 1911, a copy of this table being here given.

REPORTS ON WORKS EXECUTED.

The reports on works executed, which are contained in Memorandum "J," cover a variety of structures in various countries, and they deal with the nature of the structure, the age, external influences, general condition, materials used, and failures or deterioration. Many of these reports are quite interesting, and they tend to show in which direction failure or deterioration generally occurs in the actual work, and therefore the notes should be of some value to engineers.

GREAT BRITAIN.

X.—SUMMARY OF EXPERIMENTS CARRIED OUT BY W. C. POPPLEWELL, AT MANCHESTER, 1911.

Six square columns, gross area 36 square inches, made in ordinary way of 1·2:2:4 mixture, having longitudinal reinforcement stopped 2 inches from each end—both ends of column enlarged—kept moist. The first three were tested after 3 months and the rest after 6 months. Area of core throughout, 16 square inches. Longitudinal reinforcement consisted in four ¾-inch square bars, and the lateral reinforcement in double loops $\frac{3}{16}$-inch rod. See Minutes of Proceedings Inst. C.E., vol. clxxxviii.

Number of Column.	Length in Inches.	Longitudinal Reinforcement.			Lateral Reinforcement.					$\frac{\left(1+\overline{m-1}\frac{A_v}{A}\right)}{(1+fsr)}$	Safe Stress in Plain Concrete.	Calculated Safe Load R.I.B.A.	Ultimate Breaking Load.	Ultim. / Calcd.
		Nature.	$100\frac{A_v}{A}$	$1+\overline{m-1}\frac{A_v}{A}$	Nature.	Pitch. / Diam.	$100r$	s	$1+fsr$					
											Lb. per Sq. In.	Lb.	Lb.	
A	95 inches overall 72 inches central part	4 rods ¾-inch diam.	11·0	2·54	Double loops, $\frac{3}{16}$-in. rod	1·25	0·87	0	1	2·54	600	24,400	99,700	4·10
B	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	700	28,400	[1]	
C	60 inches overall 36 inches central part	,,	,,	,,	,,	,,	,,	,,	,,	,,	475	19,300	113,700	5·9
D	96 inches overall 36 inches central part	,,	,,	,,	,,	,,	,,	,,	,,	,,	700	28,400	[1]	
E	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	560	22,800	[1]	
F	No particulars													

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[1] Not broken at 112,000 lb.

We have drawn upon the Report by quoting some of the reports given of work executed abroad.

We give first two New Zealand examples; one a retaining wall, and the second some reservoirs and tanks.

Retaining Wall at Miramar, New Zealand.

This report is presented by Mr. James Marchbanks, M.Inst.C.E., and reads as follows :—

General Description.—A wall in reinforced concrete, 1.430 ft. in length, erected on the sea coast, partly serving as a retaining wall and partly as a parapet, with foundation at mid-tide level. The work has only recently been completed from the designs of the author, and shows signs of vertical expansion cracks. No details of cost are given.

I. Age.—The wall was built in 1910-11.

II. External Influences.—As the average rise and fall of the tide is 4 ft., from 2 to 3 ft. of the foot of the wall is immersed at every tide. The whole of the rest is exposed to the influence of moist air.

III. General Condition.—Vertical expansion cracks have appeared about midway between the buttresses and were found in some cases before the earth had been filled in behind the wall. They vary from hair cracks, at the top of the parapet portion, to cracks of 1-32 in. in width, becoming narrower down the face; some reaching the thickened toe of the wall. The worst of these cracks have been cut out and filled with cement mortar, but it is apparent that motion has not yet ceased.

IV. General Features of the Design.—The wall consists of a thin vertical and horizontal slab joined by triangular buttresses at intervals, the weight of the earth filling on the bottom slab ensuring stability. The height from the foundation to the top of the filling is 12 ft., and above this there is a parapet 4 ft. high, curved outwards to deflect waves and spray. The buttresses, 9 in. thick, are introduced at intervals of 10 ft., and the beam at the heel of the wall has a breadth of 12 in. and a depth over all of 21 in. The bottom slab is 10 in. thick and the vertical panelling tapers from 13 in. at the bottom to 11 in. at the top. It was presumed that the pressure would be uniform throughout the structure, so all the parts were treated as fully continuous.

V. Materials.—The concrete was mixed in the proportions of 1 : 2 : 3, and consisted of shingle from the sea beach not containing any stone larger than ¾ in., and unwashed clean sea sand. The Portland cement of New Zealand manufacture had to comply with the British Standard Specification of June, 1907. Mild steel with a tensile strength of not less than 60,000 lb. per sq. in. was used for the reinforcement.

VI. Methods of Construction.—The concrete was mixed by hand in small batches and transferred direct to the casings. The casing on the seaward side of the wall was constructed to the full height before any concrete was deposited, and that to the landward side was carried up in about 18-in. lifts as the concrete was deposited. The casings were left in position for a month or six weeks.

VIII. Failures or Deterioration.—Of the total length of the wall 1,180 ft. is built as a monolith in one straight line. It is thought that this is largely responsible for the cracks, as they might have been prevented by the provision of suitable expansion-joints. It is considered that better work could have been obtained if the base of the wall, situated at mid-tide level, had been kept above high water. No tests of the structure were made, and the details of design and reinforcement are shown in the accompanying section.

A Water Tower on North Island, Main Trunk Railway, and a Reinforced Concrete Tank at Mataroa.

This report is presented by Mr. F. W. Furkert, A.M.Inst.C.E., and reads :—

General Description of Water Tower.—A structure in reinforced concrete, 70 ft. in height, intended to store 10,000 gallons of water, to give effective pressure for washing out locomotives. The stand, which is 10 ft. square on top, consists of four legs, each tapering from 18 in. square at bottom to 14 in. square at top, tied together by walings and knee braces. On the summit is a system of girders supporting a tank 16 ft. in diameter and 8 ft. 6 in deep, without a top. It is in excellent condition, free from leaks and without a crack. The work was executed from the designs of the author at the end of 1908. No details of cost are given.

I. Age.—Erection completed in November, 1908.

II. External Influences.—Extreme range of temperature 10° F. to 150° F. Tank sometimes empty at high summer temperatures, and filled at different levels with ice-covered water in winter. Exposed to gales which may reach 40 to 50 miles per hour.

III. General Condition.—Excellent ; free from cracks and leaks or even a moist spot.

IV. General Features of the Design.—The legs of the stand carrying the tank are braced by six tiers of walings, and the same number of internal diagonals. The horizontals between the tops of the legs, in addition to acting as wind braces, had to project outwards and serve as cantilevers, outside the lines of stand, so as to support as much water beyond the area of the base as within it. The tank itself was designed as a tub, the hoops carrying all the stress. The whole structure, tank and stand, was designed to resist a wind pressure of 50 lb., no reduction being made for the shape of the tank. Shear stresses in the concrete were provided for by stirrups binding together the upper and lower longitudinal reinforcement. The working stresses on concrete were taken at 500 lb. in compression; and on the steel in the stand, 5 tons in tension. In the tank the steel was stressed at 7½ tons. The whole structure is reinforced with square and round steel rods, varying in diameter from ⅞ to ¼ in. The slabs forming the bottom of the tank are 6 in thick, and the walls or sides 12 in. thick at the bottom and 9 in. thick at the top.

V. Materials.—The concrete was composed of 1 part of cement, 1¾ parts of coarse sand, and 3½ parts of scoriaceous Andesite, crushed to a 1-in. gauge. This stone was weak and porous. The Portland cement conformed to the British Standard Specification. Mild steel of 30 tons tensile strength was used for the reinforcement, but for the smaller work a good deal of wrought iron was employed, with a tensile strength of 24 tons per sq. in.

VI. Methods of Construction.—The concrete was mixed fairly wet, and used at once; but in some cases, owing to the great height of the work, an hour may have elapsed between mixture and use. Care was taken to keep the steel bars in their proper position. Most of the reinforcement was bent to exact shape and laced together.

VIII. Failures or Deterioration.—No evidence of failure has occurred from any cause whatsoever. It would have been advisable to place an expansion joint in the supply and delivery pipes, both of which pass through the floor slab and are rigidly attached to it by a collar; but so far no trouble has arisen from this cause. No tests of the finished tank were made, but it was filled as soon as the profiling was removed, about one month after completion. Some sketches are appended to the report to explain the placing of the reinforcement and the details of construction.

General Description of Tank at Mataroa.—A tank formed of reinforced concrete, 26 ft. in diameter and 9 ft. deep, with a square valve-chamber on side, destined to contain 30,000 gallons of water. It was constructed in 1907 from the designs of the author, and is in first-class condition. No details of cost are given.

I. Age.—Constructed in 1907.

II. External Influences.—Exposed either empty or full to weather and sun and almost constant saturation.

III. General Condition.—First-class.

IV. General Features of the Design.—The tank was calculated as a tub, the hoops being steel rods embedded in the centre of the concrete sides, and considered as taking all the stress. The floor is entirely supported on the ground. The working stress on steel is taken at 6 tons per sq. in., and on the concrete in compression at 600 lb. The bottom of the tank is 6 in. thick, and the walls are 15 in. at the bottom, and 9 in. at the top. The concrete was composed of 1 part of cement to 5 parts of clean washed gravel, containing sufficient sand to make a watertight mixture.

VI. Methods of Construction.—The concrete was hand-mixed and placed at once, or after an interval not exceeding half an hour. The vertical reinforcement was set in the floor concrete and stayed all round by framing. The horizontal bars were then tied to the vertical ones at proper heights before each layer of concrete was placed. The joints in the bars were made by lapping for a length of 36 diameters, tying them and turning back the ends. The joints were staggered.

VIII. Failures or Deterioration.—There are no signs of failure from any cause, and no tests were made, but the tank was used a month after completion.

In conclusion, we give a report on

An Injury to a Reinforced Concrete Packing House by Electrolysis.

This report is presented by Mr. George Perrine:—

General Description.—The property in question is a large packing-house situated in Allentown, in the State of Pennsylvania. It consists of a number of connected reinforced-concrete structures of three, four and five stories and basement, with about 300,000 sq. ft. of floor space.

Age.—The buildings were completed in October, 1906.

External Influences.—The buildings are very damp owing to the acid vapours from the rendering processes, etc., and also to the presence of refrigerating pipes. They are lighted from a private plant, situated in the basement of one of the buildings by 125-volt direct-current generators. Electrical tests showed that the current would leave the positive wire at a place, and travel some distance in the reinforcement, rejoining the negative wire further on. An ordinary ground-indicator thus showed nothing wrong.

There is an electric street-railway operated from overhead trolley-wires passing in front of the packing-house. On testing, however, no appreciable current from this source was found to enter the building.

Present Condition.—In the summer of 1907, horizontal cracks appeared on the lower surface of the beam and girders, parallel with the reinforced steel. The photographs shown in an article on the failure* are typical examples of the injured beams throughout the building. The columns were also affected, and there were several cylindrical columns, about 28 in. in diameter and 18 ft. high, which were cracked from top to bottom, a crack having formed over each vertical rod. These rods are about 5 in. from the surface of the concrete.

Features of Design.—The beam and girder reinforcement consisted of plain steel bars, 1 in. in diameter along the bottom, a number of the bars being turned up at the ends. The stirrups are of 1-in. by ¼-in. steel. The main bars in the columns are of plain round steel.

There are distributed throughout the building about 3,600 iron sockets which are attached directly to the steel reinforcement. The sockets were used for supporting the woodwork for the trolley-tracks used in handling the carcasses, etc., and for supporting the electric conduits for the lighting circuits. About 600 of these sockets were used to hold the steel conduits carrying the electric wires, which caused most, if not all, the damage to the buildings.

Materials.—The concrete used in the building was machine-mixed and excellent in quality. The Portland cement used was manufactured within a few miles of Allentown; the stone used was limestone. The proportion of aggregate was 1 part of cement, 2 of sand, and 4 of stone. The pieces of concrete taken from the injured beams were as sound as that of the uninjured portions of the beam, no apparent change having taken place in the concrete.

Failure or Deterioration.—There were about 3,000 lineal ft. of beams and girders showing cracks, and from some the whole lower surface of concrete had dropped off, leaving spaces between the rods and the uninjured portion of the beams.

Where the beams were damaged the most the intermediate floor slabs contained no cracks, the reinforcement not being electrically connected with the beam steel.

The rods and stirrups were completely surrounded with scale of iron oxide ranging from 1-16 to ¼ in. in thickness. Some of the stirrups were completely destroyed and only oxide remained in their place. The oxide taking up a larger space than the iron caused cracking and flaking-off of the concrete. The concrete where ruptured had the same appearance as it would if split with wedges.

There were some concrete piers containing no steel under the cooling-pipes in the cooling-room; these were partially destroyed and crumbling.

Remedies.†—Since the publication of Mr. Brown's article further investigations have been made, and the following remedies have been carried out :—

The water, gas, and sewer pipes have been insulated just inside the building wall in the basement. The sockets in the beams and girders have been connected by return wires which lead to the dynamo and terminate in an indicator board, each room having a drop-indicator. In case of an earth the indicator gives a warning, and the difficulty can be corrected. If it is not corrected at once the lights are automatically dimmed.

Repairs.—In repairing the beams all loose concrete is removed, and the concrete and steel are thoroughly cleaned by sand-blast. After this is done 1-in. boards are clamped to the sides of the beams to be repaired, and cement mortar to which a waterproofing compound has been added is blown on the bottom of the beam by compressed air. The trade name of the waterproofing material is "Starex." It is added to the mortar before placing in the machine.

The bond between the new mortar facing and the old concrete is perfect, and the new material is very dense and shows no shrinkage cracks whatever. Mortar applied without the waterproofing substance showed shrinkage cracks and did not adhere to the old concrete. The machine used for depositing the mortar is a new and ingenious apparatus, and is doing very excellent work.

The old conduits have all been removed and new ones placed which are insulated from the structure. All junctions and joints being made waterproof.

The structural details of the buildings are apparently of good design and the workmanship of construction is of the best, and the failure is not due to any such defects.

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* H. P. Brown, *Engineering News*, Vol. 65 (1911), p. 684.

† The electrical tests are described in Mr. Brown's article. Experiments indicating the relative effects of alternating and direct current, etc., on electrolysis of reinforced concrete were given in a Paper by Mr. H. Barker and Prof. W. L. Upson, Convention of American Institution of Electrical Engineers, June, 1911.

FORMERS IN POSITION FOR CONCRETING.

CONCRETE AND REINFORCED CONCRETE AT THE HYDRO ELECTRICITY WORKS, CHESTER.

An interesting example of the usefulness of reinforced concrete and concrete in electric plants is that of the work recently carried out in connection with the new Hydro Electric Plant for the City of Chester, and of which we give a few particulars below. We are indebted to Mr. S. E. Britton, City Electrical Engineer of Chester, for our particulars and illustrations.—ED.

THE above works are erected upon the site of the old Dee Mills, which were in operation from about 1100 to 1909. The old mills were erected upon the bed of the river, which is of sandstone rock.

For the purpose of the Hydro Electric Works it was necessary to excavate the rock in the head race to a depth of 5 ft., and for the draught tubes of the turbines, to enable them to discharge into the lower river, the rock was excavated to a depth of 15 ft.

The under-water work forming the foundations for the turbines and the walls for the turbine pits are of concrete, strengthened by $\frac{5}{8}$-in. diameter reinforcing bars, as shown on the general arrangement herewith.

The proportions for the concrete are six to one, four parts aggregate, two parts sand, and one part cement. The cement used is of the best quality Portland cement, of British manufacture, and in accordance with the particulars of the British Standard Specification No. 12 for medium setting cement.

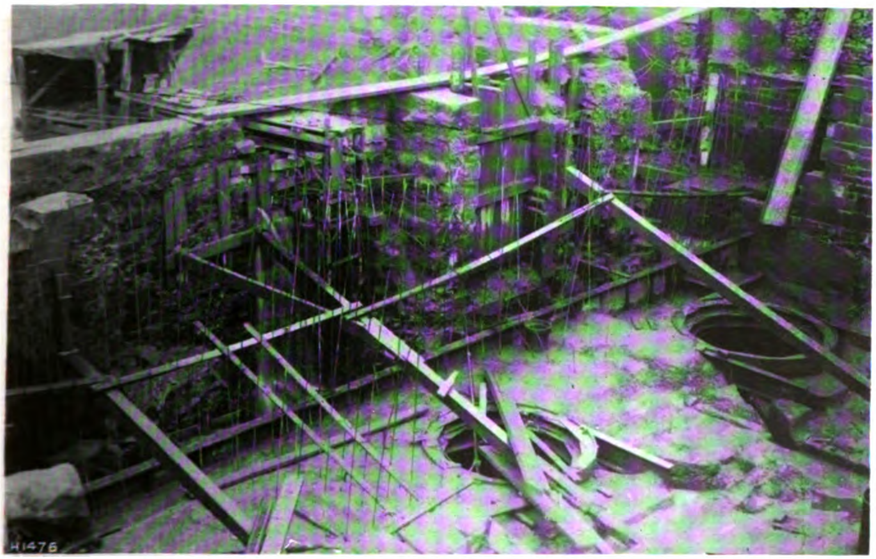
View showing Reinforcing Bars in position for the first course of Concrete.

THE CHESTER HYDRO ELECTRICITY WORKS.

The sand used is clean, sharp, and coarse river sand, composed of grains varying in size which pass through a ¼-in. square mesh.

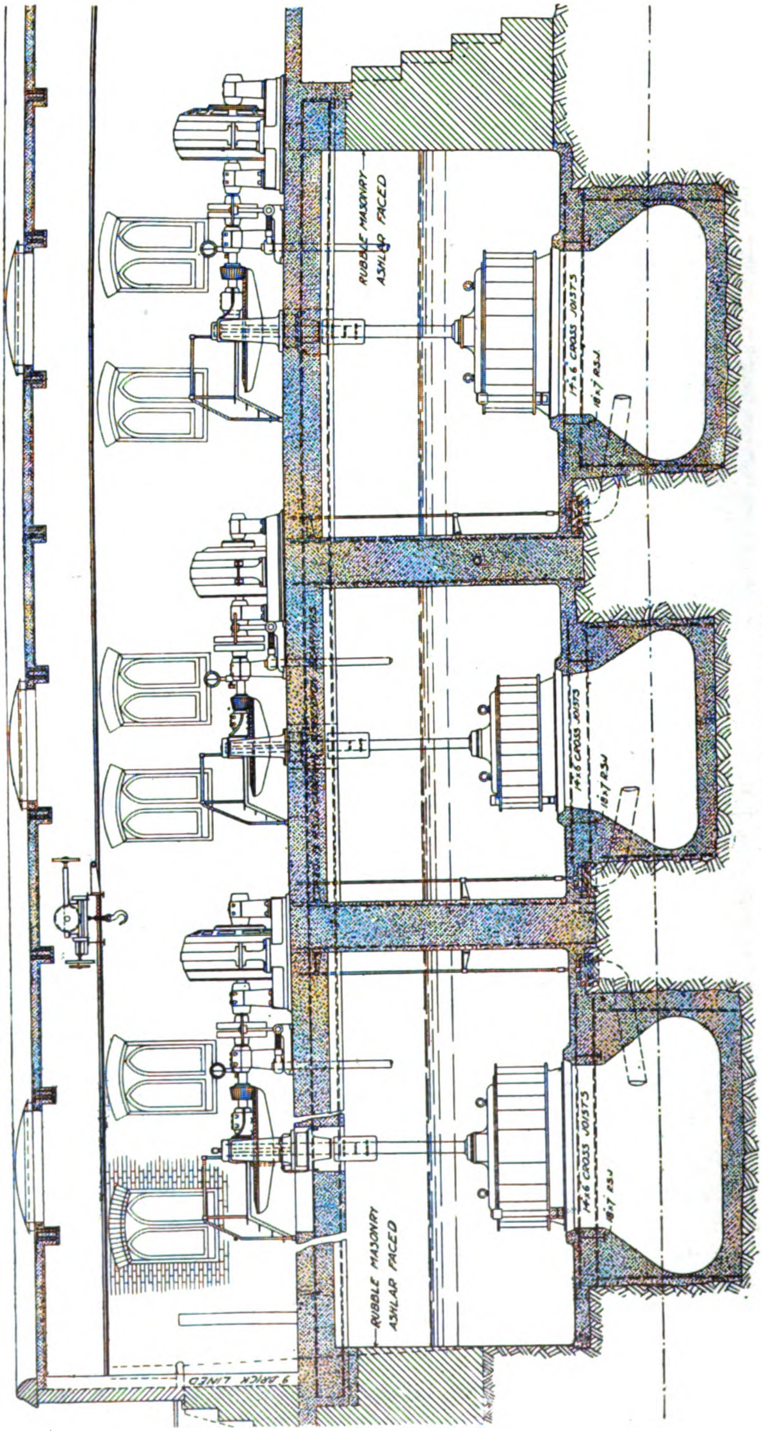
The aggregate for the plain concrete is of broken Penmaenmawr and Carrog stone, varying in size from ½ in. to 1½ in. cubes, and the aggregate for the reinforcement varies in size from ¾ in. to ¼ in. cubes.

View showing steel joists in Power House.



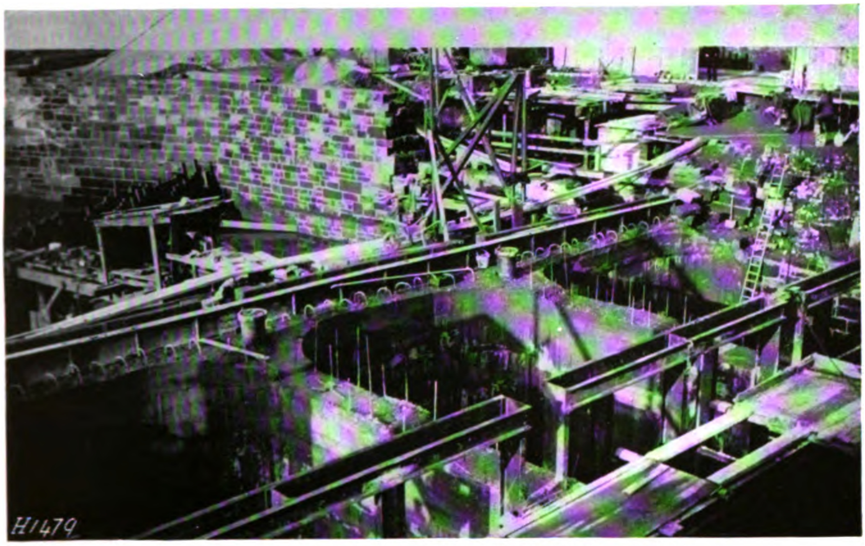
View showing concreting of steel joists in floor of Turbine Pits.
THE CHESTER HYDRO ELECTRICITY WORKS.

The power house walls are of red sandstone, lined with glazed brick. The roof of the power house is of reinforced concrete on the Kahn System, details of which are shown on the general arrangement drawing referred to above.

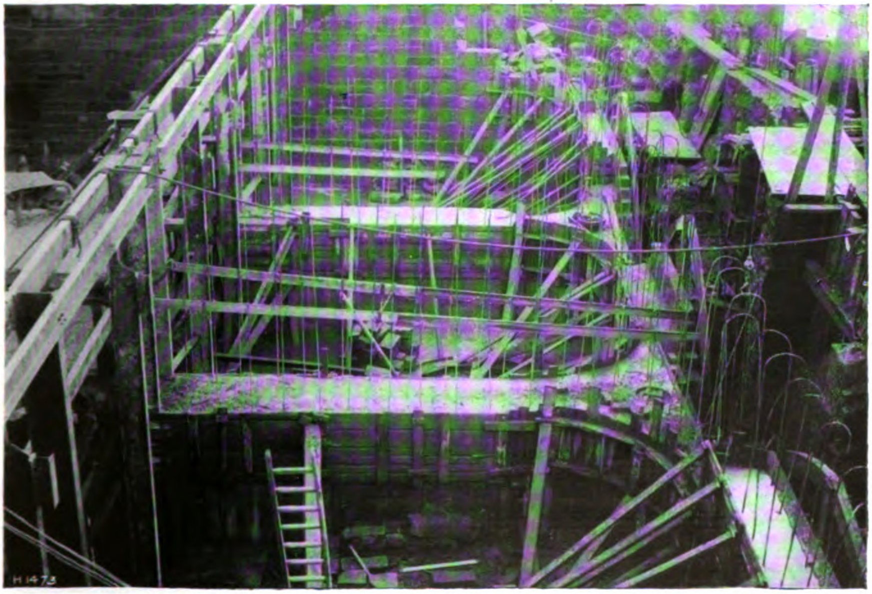


Longitudinal Section of Plant.
The Chester Hydro Electricity Works.

The power house is 89 ft. long by 24 ft. 6 in. wide, and, measured from the bottom of the head race, 36 ft. high. It is mainly constructed of steel

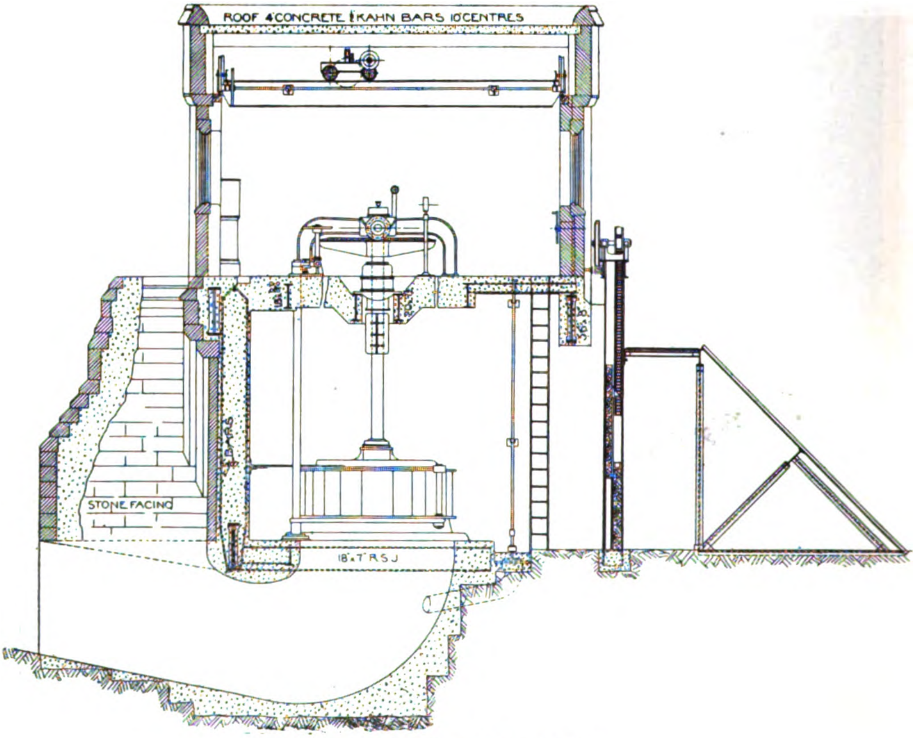


View showing concreting of Turbine Pits.



View showing concreting for Turbine Pits and steel work for Sluice Gates in position.
The Chester Hydro Electricity Works.

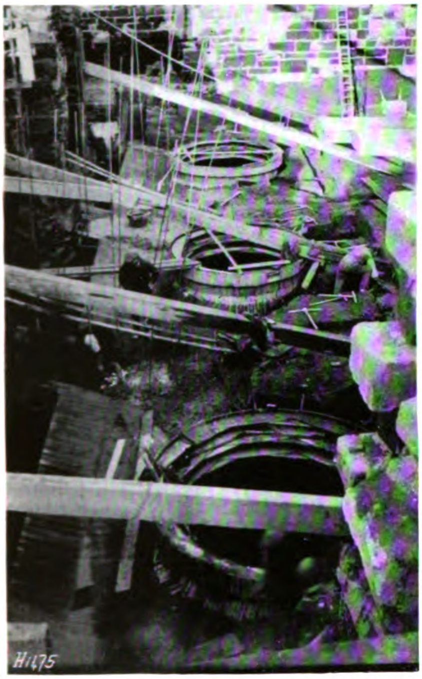
and concrete; the exterior is faced with sandstone rock and the interior with glazed brick. The foundation is on sandstone rock. The under-water work forming the head race, the three turbine pits and the tail race are of concrete and steel. On the external face of the down-stream side of the turbine pits are placed three cut waters and Gothic arches, these and the filling-in of sandstone to harmonise with the adjoining bridge. The external of the above-water part of the building, including the dynamo, switch room, and stores, is in sandstone, and contains twelve pairs of Gothic windows; the interior is lined with glazed brick. The building is covered with a flat reinforced concrete roof covered with asphalte. There are three circular glass domes in the roof, which admit of ample light and add to the general beauty of the building. The retaining wall between the bridge and the power house and 121 ft. of river wall beyond the power house has been entirely rebuilt in ashlar, with sandstone taken from the foundations of the old mills. That part of the old bridge which stands in the head race and formed part of the old mills has been restored, so as to harmonise with the general character of the bridge, and a glance at the undertaking at once impresses one with the amount of thought involved in carrying out this scheme and the improvement to the amenities.



Cross Section through Turbine Pit.

The Chester Hydro Electricity Works.

A number of photographic illustrations are given in this article showing



View showing concreting of Draught Tubes.
THE CHESTER HYDRO ELECTRICITY WORKS.

the concrete and reinforced concrete work. They are as follows:

(1) The formers in position ready for concreting.

(2) The sandstone facing of the down-stream wall of the power house and the sheeting and reinforcing bars in position for the first course of concrete for the walls of the turbine pits.

(3) Steel joists in the power house floor to carry the turbines and generators.

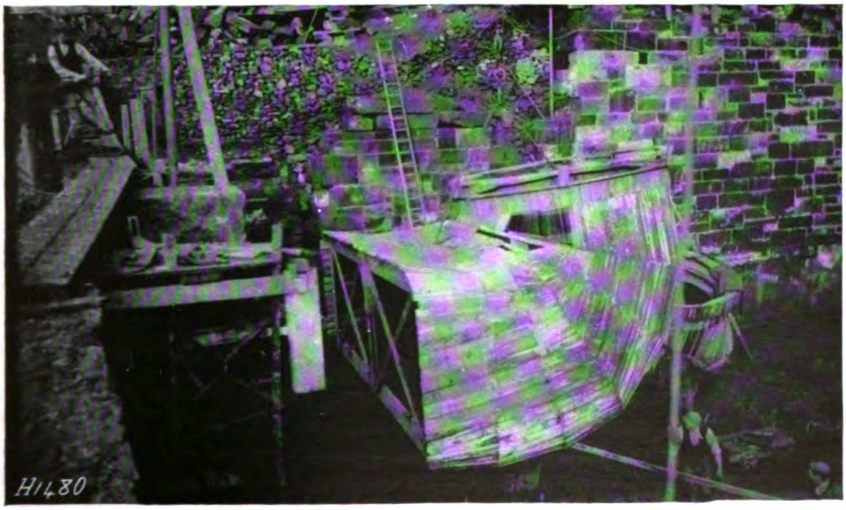
(4) Concreting steel joists in floor of turbine pits to carry the down-stream wall of the power house.

(5 and 6) Concreting for the turbine pits and the steel work for the sluice gates in position.

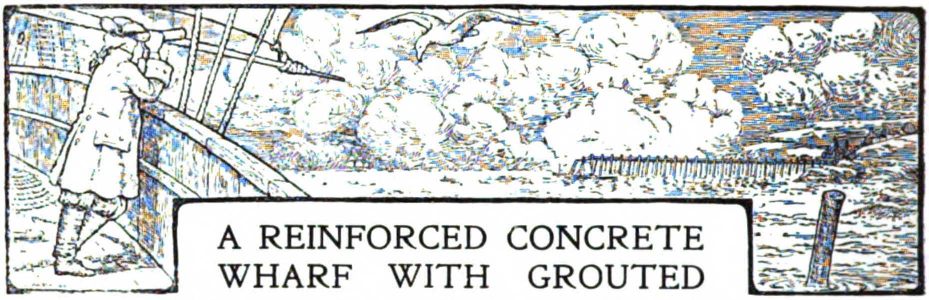
(7) The draught tubes being concreted and the reinforcing bars being placed in position.

(8) A wooden draught tube former being lowered into position.

The contractors for the building and hydraulic plant are Messrs James Gordon and Co., Knightrider Street, London, E.C.



Showing Wooden Draught Tube Former being lowered into position.
THE CHESTER HYDRO ELECTRICITY WORKS.



A REINFORCED CONCRETE WHARF WITH GROUTED FOUNDATIONS; HARBOUR IMPROVEMENTS AT ILOILO, PHILIPPINE ISLANDS.

The following is an abstract from an article by ***Mr. Wilson T. Howe*** *(formerly Assist. Engineer, Division of Port of Works, Bureau of Navigation, Manila), which appeared in "Engineering News," U.S.A., and we are indebted to that journal for their courtesy in according permission for the reproduction.—ED.*

THE city of Iloilo is situated on the southern coast of the island of Panay, about 330 miles south of Manila, and is one of the five ports of entry in the Philippine Islands. The principal export is sugar, which is shipped to Chinese ports and to the United States.

FACILITIES.

The harbour of Iloilo comprises the Iloilo River and Iloilo Strait, the latter being a good anchorage at the mouth of Iloilo River, and protected by the islands of Panay and Guimaras. Previous to the present improvements nearly all the foreign cargoes were handled by lighters between the ships in the Straits and the warehouses on the river.

Iloilo River is not a river in the strict sense of the term, but is a tortuous tidal estuary, the lower 9,000 ft. of which is navigable and available for shipping. This portion is in the shape of a huge letter S, and naturally divides itself into three reaches, each approximately 3,000 ft. in length. In former times the lower reach was merely a channel through tide flats, but at various times in recent years this reach has been improved by dredging, the material being deposited on the banks on either side, until, at the present time, it exists as a definite stream, 400 to 500 ft. in width, flowing between permanent banks and discharging into Iloilo Straits between two riprap jetties.

The only docking facilities available previous to 1908 were on the middle reach of the river, where most of the warehouses are situated. A marginal street, varying in width from 30 to 60 ft., extended the whole length of this reach, and it was supported on the river side by a light adobe-stone retaining wall founded on the natural soil at about low-tide level, and, consequently, only light craft could moor directly alongside, steamers being obliged to stand off, and passengers and cargo handled over long stage planks between the wall and ship. The depth on this reach was from 15 ft. to 18 ft. at low tide.

IMPROVEMENTS.

The first improvement at Iloilo under the American occupation was to dredge the middle and lower reaches to 18 ft. at low water, using the dredged material to fill low land on the left bank of the river, opposite the city, and an area on the right bank on the lower reach, retaining the fill and protecting the river channel by dykes of small riprap stone (*Fig.* 1) and building riprap jetties on either side of the river at its mouth. The fill on the left bank of the lower reach is now occupied by the Iloilo terminal of the Panay Division of the Philippine Railway Company, a line 70 miles long, terminating at Capiz, on the north coast of the island of Panay. The opposite fill has become a valuable site for warehouses.

The present improvement, undertaken in 1908, contemplates a definite development and provides a 15-ft. depth at low water in the upper reach, 18 ft. in the middle reach, and 24 ft. in the lower reach. The entire river was deepened to these figures in 1910. These depths are probably the greatest which it is advisable to attempt to maintain in the respective reaches.

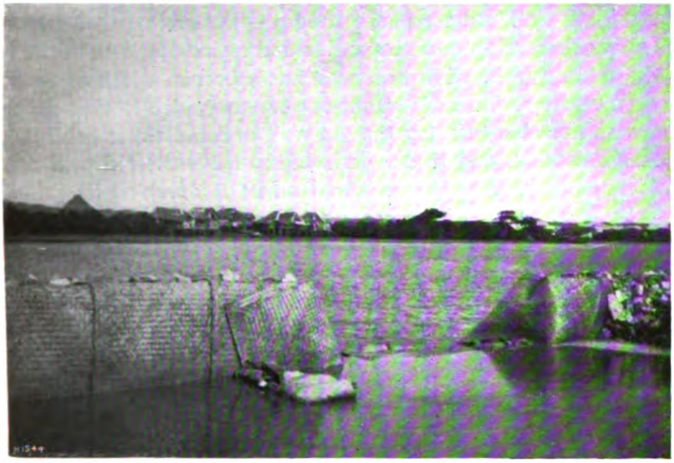


Fig. 1. Stone Dyke Backed by Mats of Split Bamboo.
HARBOUR IMPROVEMENTS, ILOILO, PHILIPPINE ISLANDS.

The material dredged from the river at this time was used to extend the previously filled areas owned by the Insular Government, and to improve several low-lying areas within the city, and also to reclaim a considerable area of beach on the left bank of the river, fronting Iloilo Straits and adjoining the railway terminal. It is proposed to develop this area by building a series of docks and slips where steamers drawing 30 ft. can berth, and to lease the property for warehouses or other purposes at the proper time.

QUAY WALLS.

For the quay walls a retaining wall was first built, but was later followed by a reinforced concrete wharf.

CONCRETE RETAINING WALL

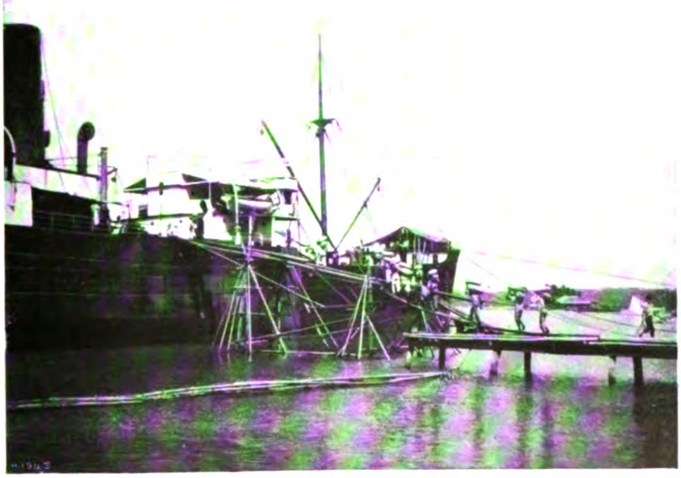


Fig. 2. Old method of Loading Sugar into Ocean-going Steamers.
HARBOUR IMPROVEMENTS, ILOILO, PHILIPPINE ISLANDS.

The second step of this improvement consists in the building of suitable quay walls along the river as funds become available, and the most urgent requirement was the replacing of the old wall on the middle reach by a new structure approximately parallel to it and in front of it, alongside of which vessels drawing 18 ft. could lie at all stages of tide, at the same time providing a marginal street with a uniform width of 80 ft. the whole length of the improvement (*Fig.* 3).

A contract was let by the Insular Government for the construction of a gravity-concrete retaining wall upon timber piles, but after doing a very small amount of work and making unsatisfactory progress, the contract was annulled, the contractor's plant purchased, and the work was completed by Government administration.

When this length of retaining wall had been completed a point was reached where the wall type of construction was becoming more expensive and troublesome on account of the proximity of the old retaining wall. The new wall has a bottom width of 15 ft. at the depth of 18 ft. below low water, and as it was necessary to dredge to that depth and width, the bank slope was not able to carry the old wall and the street behind it without considerable expensive shoring, and it was desirable to leave the old wall and its well compacted fill intact if possible. The marginal street is occupied its whole length with storehouses and offices, and carries a heavy traffic, which could not wholly be diverted during construction, and it was therefore essential to so conduct operations as to leave the street in use.

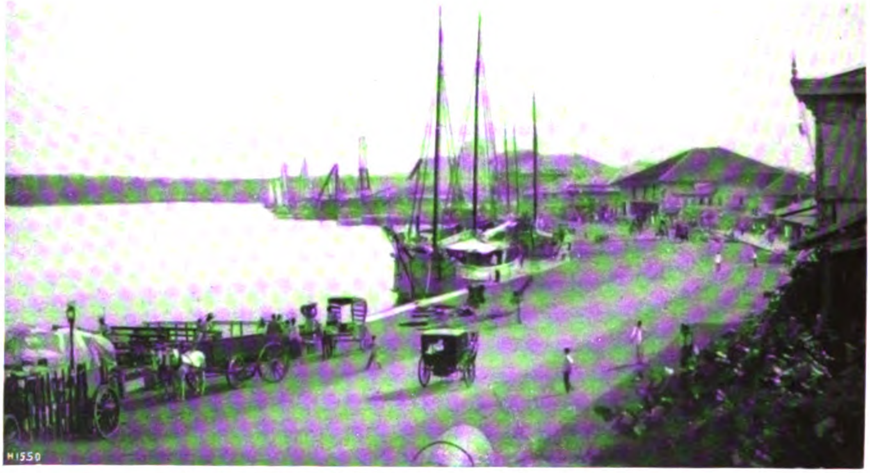


Fig. 3. Completed Quay and Marginal Street along Iloilo River.
HARBOUR IMPROVEMENTS, ILOILO, PHILIPPINE ISLANDS.

REINFORCED CONCRETE WHARF.

Plans were accordingly prepared for a reinforced concrete wharf structure which would take advantage of existing conditions to their fullest extent. The wharf consists essentially of a series of transverse girders spaced 10 ft. apart, carrying a 12-in. reinforced concrete floor. The outer ends of the girders are supported upon reinforced concrete columns 24 in. in diameter and 19 ft. 8 in. long, cast in the yard, and set in place with a derrick upon a prepared timber pile footing 17 ft. 8 in. below low water. The inner ends of the girders are carried by concrete pedestals at 2 ft. above low water, built against the old wall and carried only to the natural slope of the bank.

Rear Footings.—Each rear pedestal is supported by from four to six timber piles, at least two of which are driven on a batter, the better to resist any horizontal thrust that may come from the old wall. This group of piles is driven to a total bearing of 80 tons, it being always desired to drive each pile to 20 tons if possible, but as it was frequently impossible to secure piles of sufficient length to develop that bearing, enough extra piles were added to insure the total required bearing power per group.

These pedestals vary in size and position according to the alignment of the old wall and the number of piles necessary per group, but the size was usually dependent upon the position of the batter piles which were driven as close to the old wall as the leads of the driver in the battered position would allow. Connecting the pedestals is a concrete curtain wall 2 ft. in thickness, which serves to strengthen the old wall. The curtain wall was built to the grade of the pedestals monolithic with them; above that grade it was poured at the same time as the girders and floor.

Front Footings.—The most interesting and important feature of the work was the construction of the front foundations. The outer edge, or front of the wharf, as stated above, is carried by the line of reinforced concrete columns, spaced 10 ft. apart, one under the outer end of each of the transverse girders. This line of columns is so placed as to give a uniform width of street from the front of the wharf back to the building line of 80 ft., and as there was considerable variation in the old street width out to the irregular line of the old wall, the spans of the main girders vary from 20 to 27 ft. The latter length was the maximum nominal span allowed in the design.

Each column is carried by a cluster of piles whose total bearing is not less than 60 tons. It was attempted to drive each pile to a bearing of 20 tons, and this was usually obtained, but often four piles, and sometimes five, were required. The reason for requiring but 60 tons per group in the front footings while those in the rear were expected to develop 80 tons was due to the fact that it was uncertain what loads might come to the latter through the weakness of the old wall, and which those piles would have to carry in addition to the direct load from the new structure. When only three piles were required they were driven at the apexes of a 20-in. equilateral triangle. When four piles were necessary they were driven at the corners of a 20-in. square, and if a fifth pile was required it was driven in the centre of the square. It could usually be foretold how many piles would be required for any column by the penetration secured in the last cluster driven, and if the number were under-estimated those driven were at once sawed off at the proper grade, their positions carefully located by plumbing above the surface, and the additional pile needed was then driven in the most favourable position to give good spacing in the cluster. Since it is seldom possible to drive a pile to the exact location required it was necessary to use more than ordinary care in spotting these piles, and to hold them during driving, in order to keep them within proper limits. Frequently after locating the driven piles it would be found that one or more were so far out of position as to necessitate the driver returning to put in extra piles, those too far from line being excluded entirely from the foundation.

After the piles were driven and cut off they were enclosed in a circular sheet-iron casing, $\frac{1}{16}$ in. metal, usually 54 in. in diameter and 4 ft. high, so placed that its top was 2 ft. above the pile cut-off. To support the casing on the bottom it was necessary to throw small riprap stone around the piles until a firm bottom was made. To set the casings a wooden frame was provided, 4 ft. square and 22 ft. long, to the bottom end of which the casing was fastened with wire. The frame, or template, carrying the casing on its lower end was then picked up by the derrick and set in place, a diver guiding the lower end to ensure that the casing was at all points at least 6 in. distant from the side of any pile, while the top, being always above water, was directly under observation for line and grade. A gauge, with its zero mark 16 ft. above the top of the casing, was fastened to the frame, so that at any stage of tide the casing was easily set at the proper grade by noting that the gauge on the frame read the same as the water height on the permanent gauge.

After the casing was set to line and grade, concrete was placed in it by means of a canvas bag opening at the bottom, to a point 6 in. below the tops of the piles. When the concrete had set a diver cut the wires holding the casing to the frame and the latter was removed.

Grouted Foundations.—When the column was about to be placed gravel was deposited in the casing to the grade of the bottom of the column, and the latter was then carefully set to line and grade and braced to the falsework, it resting meanwhile upon the gravel in the casing. Thin cement grout was then poured into the gravel through a 1-in. pipe carrying a funnel at its upper end. As no pressure was used to force the grout into the gravel except the static head between the surface of the water and the upper end of the pipe, which was never greater than about 8 ft., it was found necessary to move the pipe around and grout at different points in the gravel to insure that the gravel was thoroughly cemented. After the gravel first placed was thus grouted,

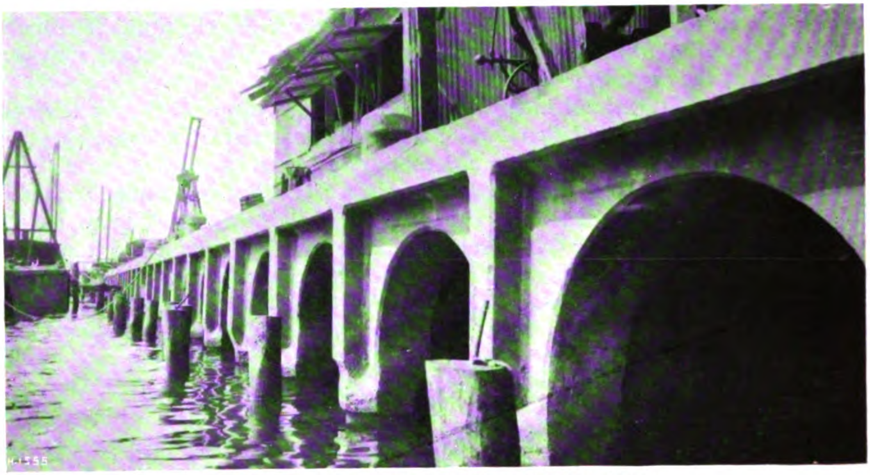


Fig. 4. View of Completed Reinforced Concrete Wharf.

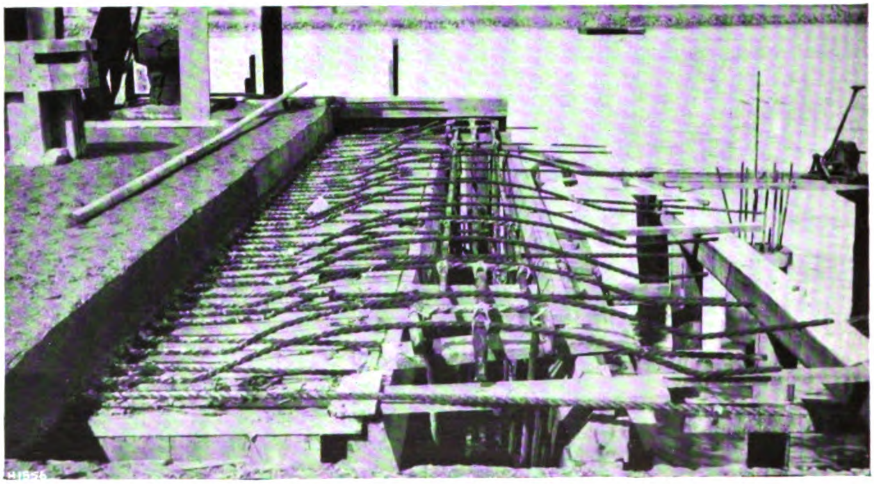


Fig. 5. View Showing Beam and Floor Reinforcement.
HARBOUR IMPROVEMENTS, ILOILO, PHILIPPINE ISLANDS.

more gravel was deposited around the column to make a layer about 1 ft. thick, which was then grouted as before. It was found necessary to thus grout the gravel in layers, because in attempting to force the grouting pipe through any considerable thickness of gravel it became clogged, and the pressure was not great enough to clear it. When the casing had been filled with concrete in this manner, and had set at least twenty-four hours, the hollow interior of the column was pumped free of water, and then filled with concrete. The pumping of the interior served as a test of the grouting, for if any part of the gravel had not been thoroughly sealed, water would soon have appeared inside the column, and indicated defective work. All the columns were easily pumped by a small hand pump, and remained dry for an hour or more, before filling with concrete.

This method of building these footings was entirely satisfactory in every way, and there are probably many similar cases where small well-confined foundations can be similarly treated, but on account of the richness of the concrete, and the unavoidable waste, due to some of the grout escaping, it would be expensive in a very large mass. In this case, where it was necessary that a perfect result be obtained, several advantages are apparent. It obviated placing concrete under water, and it excluded the necessity of pumping and the coffer-dam method, which would have been out of the question for such small foundations.

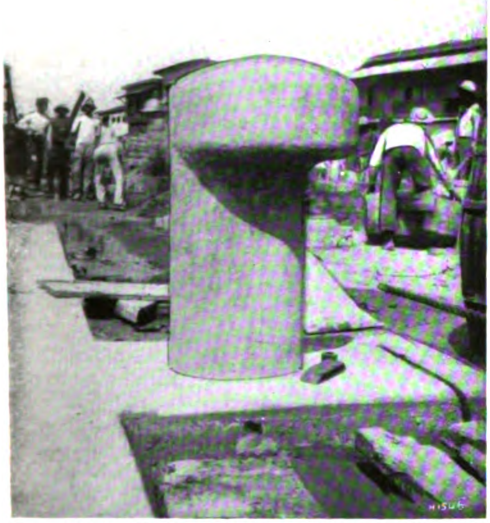


Fig. 6. A Reinforced Concrete Mooring Post.
HARBOUR IMPROVEMENTS, ILOILO, PHILIPPINE ISLANDS.

The setting of the columns was rendered simple, as they were placed on the gravel in the casing, and so had sure support during the operation of filling the casing. The difficulties of setting columns on a bed of green concrete under water must be evident. The manipulation of the column while attaining line and grade would so agitate fresh concrete as to cause it to separate, or it would be necessary to support the column from above and then bring the concrete up to it. In the method described the column was

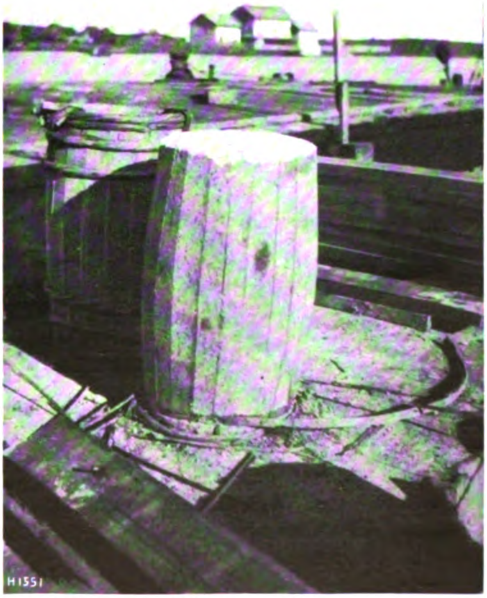


Fig. 7. Concrete made under water.
HARBOUR IMPROVEMENTS, ILOILO, PHILIPPINE ISLANDS

lowered directly on to soft gravel which had previously been brought to the proper grade. If the column proved to be too low it was raised slightly and more gravel poured through the interior of the column. If too high, the column was dropped upon the gravel to compact it, or it was twisted and moved to work it into place and nothing was disturbed thereby.

That good concrete was made by this method was proved by experiment, and it is thus described in a report made at the time:

> An empty cement barrel (*Fig.* 7) was lowered into the same depth of water in which the footings are made, gravel placed therein by means of a 6-in. pipe to a depth of about 8 in., and then the grout pipe inserted into the gravel, care being taken to have the pipe coincide with the axis of the barrel. The gravel was then grouted in the same manner as is done in the foundation, more gravel placed in the barrel to the depth of about 12 in., and more grout poured, and so on until the barrel was filled with gravel and grouted. The sample was taken from the water after about 40 hours, the barrel was cut away, and the result was an entirely satisfactory block of concrete. Some very small pit holes appeared in the surface, but as a whole the surface was as smooth as is generally obtained in ordinary form work. The result shows that the grout will flow freely for at least 8 or 9 in. in all directions from the pipe. Eight buckets of grout were used in the barrel of gravel.

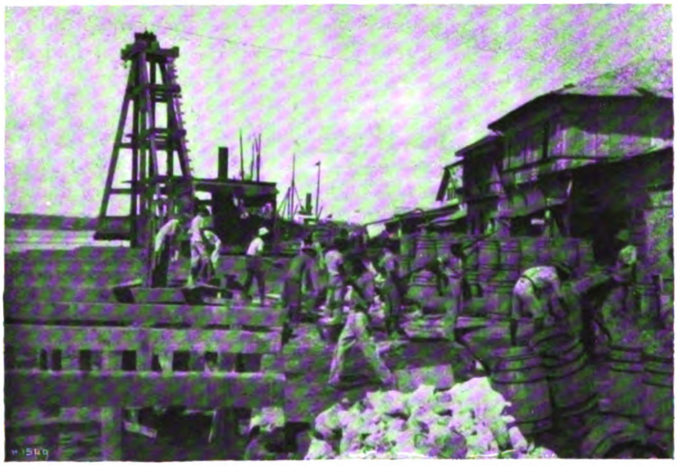


Fig. 8. View of Pile Driver.
HARBOUR IMPROVEMENTS, ILOILO, PHILIPPINE ISLANDS.

Backfill.—After the columns were set, riprap was placed along the front line of the wharf to a depth of 16 ft. below low water, and the slope back-filled to the tops of the rear foundation blocks with riprap and mud. The latter was to insure that the piles supporting the blocks would be fully protected from teredo, while the riprap was to make a stable and permanent slope and to prevent scour.

Superstructure.—The construction of the superstructure offered no unusual problems and followed the usual practice in reinforced concrete. A length of 20 ft. of wharf, or two spans, was made at each operation, joints being broken in the centre of the floor spans, a portion of the slab being figured to act with the girders as a T-beam. At expansion joints the break was made at the edge of the girders through the floor, thence along the rear side of the spandrel and through the centre of the arch. The concrete mooring posts (*Fig.* 6) were cast in place at the same time as the wharf floor. They are located 60 ft. apart the whole length of the wharf. Mooring posts of concrete have been used at various places on work done in the Philippines, and have proved satisfactory. As each mooring post contains less than one-third of a cubic yard of concrete, and about 100 lb. of reinforcing steel, they are much cheaper than the ordinary cast-iron posts or cleats.

Falsework.—The whole construction was carried out by the use of falsework. Bents of three or four piles each, as required by circumstances, were driven to grade

10 ft. apart midway between girders, and capped at 7 ft. above low water. From these caps the piles were driven for foundations by a skid driver. As the pile driver finished its work and moved ahead, the caps were removed, the piles cut off at 4·5 ft. above low water and recapped. From this trestle as a working platform the columns were set, and it also carried the forms for the superstructure.

It was not feasible to operate the driver on this low trestle, as it was not only below high tides twice every day, but the driver had to work partially on the old street to manœuvre for position to drive the batter piles, hence it was necessary to have the trestle at that elevation for driving, while to carry the forms for the superstructure it was necessary to cut off below the under-side of the deck. All but the outside piles of each bent were lost, it being of course impossible to recover them after the superstructure was built. A feature of the falsework was its arrangement whereby a support was left under the centre of the floor slab after the remainder of the forms were removed. Forms were removed from the girders and slabs after seven days, but the centre support was left at least fourteen days, and in most cases longer.

Pile Driving.—Generally the pile driver used was of special design in order to drive the batter piles (*Fig.* 8). The head block was supported by the ordinary four-legged tower, 36 ft. high, but the two forward legs were spread outward at the bottom to give a batter of one horizontal to five vertical. Two brace legs extended backward from the vertical legs at the rear of the head block. The head block overhung the front battered legs about fifteen inches and carried the swinging leads. The leads were made as light as possible consistent with their duty and were of single 3 in. by 12 in. yellow pine, with angle-iron hammer guides, and were 65 ft. long. They were connected together at the bottom by a timber yoke, and at three other points in the lower half of their length by yokes of strap iron, and were fastened again at their tops. No connections were possible in the upper half-length of the leads as they had to be free to slide up and down over the sheaves in the head block.

Concrete.—Concrete was mixed by hand and shovelled directly into the forms. The concrete in the girders and floor was mixed on the floor last in place. The bottom of the main girders was only 2 ft. above low water, but no attempt was made to make the forms for them watertight, work being so arranged as to begin concreting on a falling tide as soon as the form could be cleaned after the tide had left it, and by the time the rising tide had reached the concrete it had been in place long enough so that no injury was done to it.

The concrete in the rear footings was deposited under water by means of a 6-in. tremie, and it proved more satisfactory to finish the tops of the pedestals under water at high tide, than to finish them in the dry at low water. The top of the finished pedestals was only 2 ft. above low water, and when it was attempted to finish them in the dry, the wash from passing launches so washed the concrete as to make it extremely difficult to get good results.

Sand and gravel were piled always near the mixing platform, and were brought to it by men working in pairs carrying the materials in half cement barrels slung by wire from a pole across their shoulders.

All reinforced concrete was mixed in the proportion of 1 : 2 : 4, while that placed in the foundations under water was proportioned 1 : 2½ : 5.

Labour.—Nearly all the labour on this work was done by Filipinos, under a single American foreman. There were on the rolls a Japanese blacksmith, and at times three or four Japanese or Chinese blacksmith helpers and carpenters. The pile-driver engineer was a Filipino, and as good an operator as could be desired, although he was not always as capable of keeping his engine in condition, or of making repairs as a white. Night watchmen were East Indian Sikhs, who had usually seen service in the British Indian Army; these men are found everywhere in the East, and seldom work except as watchmen.

This work at Iloilo, as well as all harbour work and the lighthouse work in the Philippines, is under the Bureau of Navigation, of which Mr. Frank P. Helm has been the Director for several years. Mr. Howe was in local charge at Iloilo during the completion of the retaining wall, and at the beginning of the reinforced-concrete wharf, and was later Principal Assistant Engineer of the Division. The work was completed by Mr. Harry A. Thompson as Assistant Engineer in local charge.

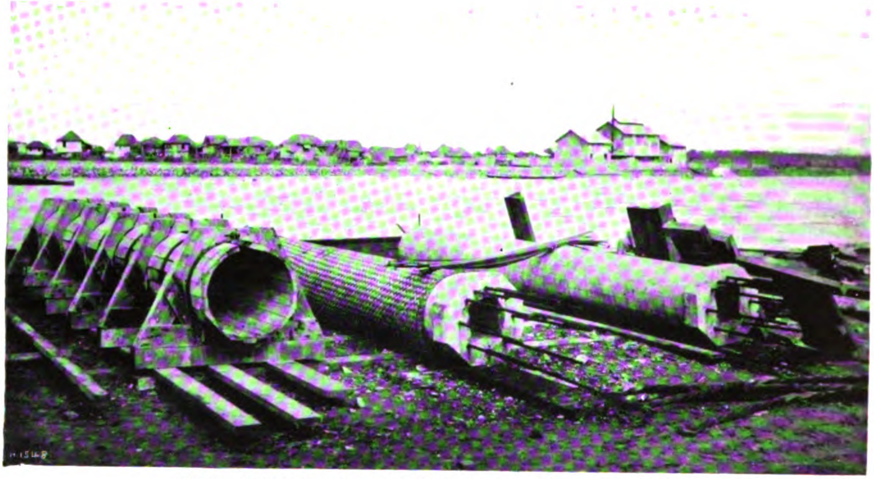
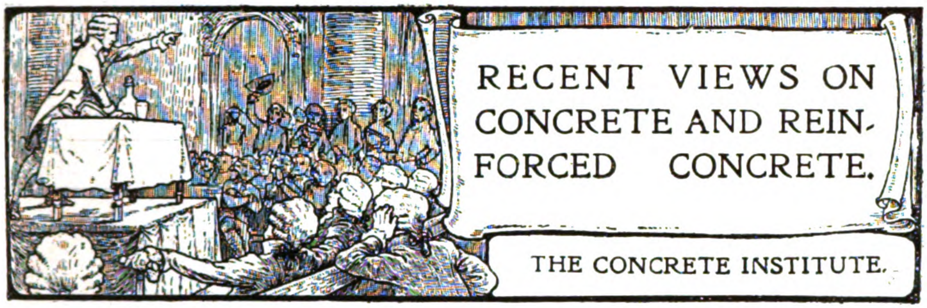


Fig. 9. Concrete Columns in Casting Yard with Assembled Iron.
HARBOUR IMPROVEMENTS, ILOILO, PHILIPPINE ISLANDS.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

SOME FALLACIES IN CEMENT TESTING.

By W. LAURENCE GADD, F.I.C., M.C.I., etc.

The following is an abstract of a paper read at the Forty-first Ordinary General Meeting of the Institute.

INTRODUCTION.

THE object in this paper is not so much to question the accuracy of the testing performed by inexperienced operators as to draw attention to what are, in my opinion, fallacies underlying some of the recognised or suggested processes of testing Portland cement; and at the outset I find myself at variance with the British standard specification itself.

The standard specification stipulates that before any sample of cement is submitted to certain tests it " shall be spread out for a depth of three inches for twenty-four hours in a temperature of from 58 to 64 degrees Fahrenheit."

The object of this procedure appears to be twofold—*i.e.*, (*a*) to cool the cement to the normal temperature of the atmosphere, and (*b*) to obtain conditions similar to those governing cement which has lain in sacks or casks for two or three weeks—*i.e.*, during the possible period between shipment and use.

As regards (*a*) this can be very simply done without exposing the sample to air As regards (*b*) I have made the following experiments :—

EFFECT ON SETTING TIME OF STORAGE IN SACKS.

Two large samples of cement, one freshly ground and the other ground about a month previously, were filled into sacks, tied up, and put aside in the warehouse at each of six different factories on the Thames and Medway and in the Isle of Wight. Samples A, B, C, D, E, and F were rotary kiln cements; samples G, H, J, K, L, M were chamber kiln cements.

Specimens of all these were despatched to me at the time of filling the sacks. After two weeks the contents of the sacks were thoroughly mixed and a second set of samples again sent to me, the remainder of the cements being returned to the sacks and stored for a further two weeks, when the same procedure was again gone through.

The three sets of samples were tested for setting time with the following results :—

TABLE A.

SETTING TIME (MINUTES).

Cement.	Date Ground.	First Samples.		Second Samples.		Third Samples.	
		Initial.	Final.	Initial.	Final.	Initial.	Final.
A	8/6/13	110	170	35	125	60	120
B	4/7/13	105	210	70	205	60	120
C	2/6/13	102	357	35	365	60	240
D	4/7/13	135	330	60	375	90	285
E	6/6/13	140	335	100	400	135	420
F	5/7/13	162	402	185	455	165	480
G	2/7/13	105	255	235	445	300	480
H	26/5/13	65	185	180	435	300	480
J	7/7/13	70	130	35	155	Not received	
K	3/6/13	80	170	55	235	Not received	
L	7/7/13	75	405	55	370	90	360
M	9/6/13	85	220	45	345	60	270

EFFECT OF AËRATING IN LAYERS THREE INCHES DEEP.

Samples of the cements as received from the works were laid out for twenty-four hours, in accordance with the British standard specification, and then tested, with the following results :—

TABLE B.

SETTING TIME (MINUTES).

	First Sample.			Second Sample.			Third Sample.		
	As Received.	Aër. 24 h.	Aër. 7 d.	As Received.	Aër. 24 h.	Aër. 7 d.	As Received.	Aër. 24 h.	Aër. 7 d.
A	I 110	60	75	I 35	63	40	I 60	60	35
	F 170	165	225	F 125	213	145	F 120	135	70
B	I 105	55	55	I 60	70	45	I 60	45	35
	F 210	145	160	F 150	205	120	F 120	120	70
C	I 102	50	55	I 35	30	20	I 60	30	15
	F 357	365	430	F 365	365	245	F 240	255	240
D	I 135	70	65	I 60	55	30	I 90	90	45
	F 330	430	440	F 375	445	430	F 285	330	430
E	I 140	75	75	I 100	95	85	I 135	105	105
	F 335	315	435	F 400	380	505	F 420	375	470
F	I 162	155	145	I 185	190	105	I 165	165	165
	F 402	440	445	F 455	430	510	F 480	540	510
G	I 105	100	20	I 235	185	15	I 300	210	10
	F 255	340	125	F 445	425	110	F 480	480	50
H	I 65	45	9	I 180	165	15	I 300	275	15
	F 185	200	85	F 435	360	90	F 480	530	55
J	I 70	50	25	I 35	45	10	—	—	—
	F 130	110	120	F 155	255	95	—	—	—
K	I 80	40	9	I 55	50	10	—	—	—
	F 170	115	47	F 235	200	55	—	—	—
L	I 75	60	80	I 55	50	95	I 90	75	105
	F 405	420	365	F 370	410	410	F 360	345	440
M	I 85	65	60	I 45	55	25	I 60	60	105
	F 220	260	360	F 345	370	160	F 270	345	265

The results of the tests show that there is no relation between the effects of aërating cement for twenty-four hours and storing in sacks for two weeks or a month; further that the setting time is differently affected when the same cement is aërated or stored in bulk in different localities or at different periods. In some cases the effect of twenty-four hours' aëration is the opposite to that produced by storage; and storage or aëration at one period has an opposite effect to storage or aëration at another period.

TABLE C.

AËRATION FOR TWENTY-FOUR HOURS COMPARED WITH STORAGE IN SACKS FOR TWO WEEKS: EFFECT ON SETTING TIME SHOWN IN MINUTES ACCELERATED OR RETARDED.

—	First Two Weeks.								Second Two Weeks.							
	Twenty-four Hours Air.				Two Weeks Sack.				Twenty-four Hours Air.				Two Weeks Sack.			
	Initial.		Final.		Initial.		Final.		Initial.		Final.		Initial.		Final.	
	A.	R.	A.	R.	A.	R.	A.	R.	A.	R.	A.	R.	A.	R.	A.	R.
A	50	—	5	—	75	—	45	—	—	28	—	88	—	25	5	—
B	50	—	65	—	45	—	60	—	—	10	—	55	No change		30	—
C	65	—	—	100	67	—	—	8	5	—	No change		5	—	No change	
D	52	—	—	8	75	—	—	45	5	—	—	70	—	30	90	—
E	65	—	20	—	40	—	—	65	5	—	20	—	—	35	—	20
F	7	—	—	38	—	23	—	53	—	5	25	—	—	5	25	—
G	5	—	—	85	—	130	—	190	50	—	20	—	—	65	—	35
H	20	—	—	15	—	115	—	250	15	—	75	—	—	120	—	45
J	20	—	20	—	35	—	—	25	—	10	—	100	Not received			
K	40	—	55	—	25	—	—	65	5	—	35	—	Not received			
L	15	—	—	15	20	—	35	—	5	—	—	40	—	35	10	—
M	20	—	—	40	40	—	—	125	—	10	—	25	—	15	75	—

This appears to me to effectively dispose of the somewhat prevalent idea that changes in setting time are due to some inherent property of different cements. The erratic behaviour found is common to all the samples tested, the composition of which varied within considerable limits, the lime contents, for instance, ranging from 64 to 59 per cent.

The retardation or acceleration of setting time on storage or aëration cannot therefore be due to peculiarities in the cements themselves, but must be due to chemical changes brought about by the absorption of some constituent present in the atmosphere.

Cement has a strong affinity for moisture in the first place, and for carbonic anhydride in the second place, and these constituents are present in the atmosphere in variable proportions at different times and in different localities.

From former experiments and reasoning, I have held the opinion that absorption of moisture results in a retardation of setting time; whilst absorption of carbonic anhydride produces an accelerating effect. Cement exposed to both influences will therefore have its setting characteristics affected one way or the other according to the relative amounts of moisture and carbonic anhydride absorbed, the net effect being the resultant of the two opposing forces.

In order to test this theory, I have made some laboratory experiments, where the conditions can be under control and standardised, which is rarely possible in so-called "practical" tests.

The results indicated that pure dry air has no effect upon the setting time of cement, the loss constituents remaining practically constant.

On the other hand, the effect of moist air free from carbonic anhydride is distinctly marked, although the percentage of moisture absorbed is comparatively small.

The acceleration of setting time by absorption of carbonic anhydride is clearly proved.

Some further experiments were made with a cement specially obtained, ground from fresh rotatory clinker without any addition, in the form of gypsum or steam, for the purpose of regulating the setting time. When received this sample had a practically instantaneous set, and could not be gauged with 30 per cent. of water.

In this case the cement was subjected to *successive* treatment, a portion being withdrawn from the tube for chemical and setting-time tests after each experiment, the remainder being subjected to further treatment.

I do not put forward the results obtained from these tests as final, but the results already given seem to clearly indicate that the change of setting time which a cement undergoes on exposure to air depends entirely upon the relative amounts of moisture or carbonic anhydride which it absorbs. Therefore to aërate cement before submitting it to a setting-time test is a misleading operation.

FINENESS.

The British standard specification stipulates that the fineness of grinding shall be such that not more than a certain percentage of residue shall remain upon a sieve of a stipulated mesh, under the conditions of the test. It is obvious that the most important point in this connection is to ensure that the sieves used shall be of standard and definite dimensions, and this is provided for by the following clause:—

> "The sieves shall be prepared from standard wire, and the diameter of the wire for the 5776 mesh shall be ·0044 in. and for the 32400 mesh ·002 in. The wire cloth shall be woven (not twilled), the cloth being carefully mounted on the frames without distortion."

The standard specification therefore stipulates that for the first-named sieve there shall be 76 warp and 76 weft wires of a definite diameter; and for the second sieve 180 warp and 180 weft wires of a definite diameter per square inch.

When sifting cement through a sieve to obtain the proportion of particles too large to pass through the interstices between the wires, the size or area of the individual holes appears to be the only condition of importance; and it is to be assumed that the intention of the framers of the specification was to ensure this condition being standard.

If a definite number of wires of a definite thickness be *equally* spaced throughout the unit of measurement, the spaces between the wires will be of definite and equal area; but the weaving of wire cloth has not yet attained such a standard of excellence as to ensure that the wires (especially in the finer counts) are spaced equally throughout the piece, or even throughout any individual inch.

I submit that the size or area of the holes in a sieve is the real standard and should be stipulated, the actual diameter of the threads, or their precise number per inch, being of secondary importance.

In the course of my duties, it falls to me to examine and to accept or reject numerous pieces of sieving cloth for use in a number of cement works and testing laboratories, and I have formulated a specification for my own use which aims at a standard sieve, whilst at the same time recognising and allowing for the great difficulty of weaving cloth of this nature with extreme accuracy.

This specification, for 180^2 sieves, I state as follows:—

1. The standard area of the holes in inches is $·00355^2$.
2. The equivalent mesh, calculated from the actual average area of the holes, as measured, shall fall between 176^2 and 185^2.
3. The mean variation from the standard width of holes shall not exceed 10 per cent.
4. Not more than 10 per cent. of the holes measured shall exceed a variation of 15 per cent. from standard.

Another point which appears to be overlooked is the size of the sieve itself. The British specification stipulates that 100 grams of cement shall be sifted for a period of fifteen minutes, but does not specify the total area of the sieve to be used. I have seen in use sieves varying in size from 4 in. diameter to 9 or 10 in. square; and it is obvious that the same weight of cement, sifted for the same period of time, will be more effectively sifted over a larger area than over a smaller one.

SPECIFIC GRAVITY.

The specific gravity test is now used in place of the old method of taking the weight per striked bushel, which has for some time been discredited.

The weight per bushel had no real bearing upon or relationship to the degree of calcination, but was chiefly influenced by the fineness of grinding.

The specific gravity test is still retained in the British standard specification, and is considered by most people to fulfil the functions formerly attributed to the bushel weight test—viz., to detect the degree of burning to which the clinker has been subjected, or, in other words, it is a test for under-burned cement. This, however, is a fallacy.

The specific gravity of carbonic anhydride and of water being ·88 and 1·00 respectively, it will be readily seen that comparatively small proportions of these substances, absorbed from the atmosphere, are sufficient to reduce the gravity of cement to a material extent.

Butler has shown that if the absorbed water and carbonic anhydride be expelled by igniting the cement, the specific gravities of cements of various makes become so nearly identical as to afford no indication of quality.

The conclusions reached by Butler were: (1) That the specific gravity of cement is no indication whatever of proper calcination. (2) That the specific gravity depends upon the age of the cement and the opportunities it has had of absorbing water and carbonic anhydride from the air.

These conclusions are quite in accord with the experience and the opinion held by myself for some time past.

In 1904 or 1905 F. M. Meyer found, as the result of some hundreds of tests on freshly burned clinker, that the highest specific gravity was obtained when the clinker was burned at a temperature of 1,290° to 1,370° C. This clinker gave cement which was expansive and unsound.

As the burning temperature was raised, the specific gravity was decreased, but the clinker became sound.

My own experience is that when taken freshly from the kiln, the specific gravity is practically the same whether the clinker be well burned or under burned, provided the carbonic anhydride has been all, or nearly all, expelled from the chalk. This is in accord with some results published by Redgrave, who found the specific gravities of four samples, taken from one place in the kiln, to be as follows:—

	Specific Gravity.
1. Yellow, slack burned clinker	3·16
2. Good clinker	3·17
3. Very lightly burned, showing spots of lime	3·20
4. Over-burned vitreous clinker	3·19

The specific gravity of cement being merely a measure of the degree of aëration which the sample has received, and the finer particles being naturally more absorbent of water and carbonic anhydride than the coarser pieces, it follows that a finely ground cement, containing much flour, will more rapidly have its original specific gravity reduced by aëration than will a coarsely ground sample, and would thus, falsely, appear to be the more lightly burned of the two.

It may be thought that granting the specific gravity is merely a measure of the water and carbonic anhydride absorbed, and is no indication of calcination; it might be advisable to retain the test with the object of detecting dangerous natural cements manufactured on the Continent, which cements are characterised by a high loss on ignition. Personally I am unable to agree with this for several reasons. Firstly, the direct method of estimating the loss on ignition is more accurate than a determination of specific gravity, which is an indirect method, and, moreover, a more difficult and uncertain operation. Secondly, an artificial cement, especially if finely ground, exposed to air or kept in a damp store for some time, may have its gravity reduced to a figure quite as low as that of many natural cements. Thirdly, no single test of this nature is sufficient to determine whether a sample is or is not a natural cement. The only certain guide is a chemical analysis, and having this data, the specific gravity becomes superfluous.

STANDARD SAND.

There is a somewhat general idea that tensile or crushing tests of cement with standard sand represent the best results of which the cement is capable. This is erroneous. Sand tests do not give the highest results which can be got out of the cement, but give results which are standardised, and therefore comparable with those obtained by different operators.

The standard sands employed and specified in different countries vary in size to some extent, as shown in the following table:—

TABLE D.

RESIDUE ON SIEVES, PER CENT.

	20^2.	30^2.	40^2.
German sand	17·4	100	—
French sand	91·0	100	—
Austrian sand	0	—	100
American sand	0	100	—
English sand	0	100	—

These differences in size of grain doubtless have their effect upon the results obtained. Actual experiments indicated that the crushing resistance of concrete made from the same cement varies not only with the size, but also with the character of the aggregate. On comparing the results of the tests with standard Leighton Buzzard sand, all passing a sieve of 20 mesh but retained on a 30 mesh, and those with pit sand passed through a $\frac{1}{4}$-in. mesh only, an apparent anomaly is observed, as the apparently larger grained pit sand gives a less crushing resistance than the standard sand. This is not really anomalous, because although the pit sand was only passed through the $\frac{1}{4}$-in. screen, it contained a considerable quantity of very fine stuff which would probably have passed a 50^2-mesh sieve.

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The whole of the specimens were kept in damp air only until due for crushing.

AUTOCLAVE TEST.

This test, recently proposed by Mr. H. T. Force, in charge of testing materials on the Delaware, Lackawanna, and Western Railroad, of Scranton, Pa., is merely a revival of Dr. Erdmeyer's high-pressure steam test introduced in Germany about 1881, and rejected by German cement experts as being unreliable and misleading. In the words of Professor Gary, of the Royal Bureau of Material Testing, it is even less adapted to distinguish useless cements from useful cements than the usual methods of determining constancy of volume. According to Dr. Cushman, of Washington, the details of the test have been several times revised during the last twelve months, but the procedure is now as follows:—

For each test three neat briquettes are made, and after twenty-four hours in a moist closet these are weighed and then placed in the autoclave, sufficient water being added to cover them. Pressure is then raised by heating the apparatus by gas burners or other suitable means, the time taken to raise the pressure to 295 lb. per square inch being not more than one hour.

The pressure is maintained at 20 atmospheres for a further period of one hour, at the end of which time the autoclave is slowly blown off, the briquettes removed (when their condition permits) and placed in the moist closet for one hour. They are then re-weighed and broken in the cement-testing machine in the usual manner. The tensile strength so obtained is compared with that of twenty-four-hour neat briquettes kept in moist air, and must show an increase of at least 25 per cent. over the latter. The autoclave briquettes must also develop a strength of at least 500 lb. per square inch, and the gain in weight must not be greater than 1 per cent. Expansion bars, 1 sq. in. in section and 6 in. long, are also made up and tested for expansion after twenty-four hours in the moist closet and two hours in the autoclave. The expansion of these bars must not exceed one-half of 1 per cent.

I hold that growth of strength by age is of less importance and is not such a criterion of quality as is generally considered. Modern cements prepared from purer clinker and much more finely ground than formerly attain a strength approximating to the maximum much more quickly, and it is evident that a cement which attains, say, ·8 of its maximum strength at short dates, has less margin for growth than one which only developes ·5 of the maximum in the same time.

The stipulated pressure to be maintained in the autoclave (20 atmospheres) is needlessly high and serves no useful purpose.

Quite recently the autoclave test has been subjected to critical examination, both in the United States and in Canada; and the conclusions arrived at are that a case for its adoption has not been made out.

FREE LIME.

No theory connected with Portland cement has obtained a stronger hold, or has attained such hoary antiquity, as the idea that unsoundness of cement is due to free lime locked up within the particles of the ground material. In fact, this theory has been for so long accepted that to question it may possibly be met with derision.

The improvement in soundness, brought about by the exposure of cement to a damp atmosphere, lends some apparent support to the contention that free lime is thereby slaked and rendered harmless; but it is rather difficult to understand how the small amount of moisture absorbed from the air penetrates the particles and slakes the free lime when the enormously greater quantity of water used in gauging the cement fails to touch it. Furthermore, unsound cement stored for some time in air-tight receptacles, in which presumably no slaking of free lime can occur, becomes perfectly sound.

Exposure of cement to air for a few days sometimes results in an increase in the amount of expansion, as tested by the Le Châtelier method, and this increase is nearly always proportionate to the amount of aëration undergone—*i.e.*, the thinner the layer in which the cement is laid out, the greater the increase of expansion.

We know very little yet of the properties of lime in a state of solid solution. It is stated to be crystalline and to hydrate slowly; but if the solid solution theory be correct, crystalline free lime is present in considerable quantity in all Portland cements, whether sound or unsound, and it has not been satisfactorily explained why the lime hydrates without expansion in one cement but does so with destructive force in another.

It is also well known that a low-limed cement is often more unsound than a high-limed cement, which again is antagonistic to the free lime theory.

My own view is that unsoundness in cement is probably due to the presence of an abnormal silicate, perhaps dicalcium silicate, which is an unstable compound and slowly disintegrates with an increase in volume. The phenomenon of "creeping clinker," known to cement makers, is an illustration of the disintegration, with increased volume, of dicalcium silicate, which is formed when clinker contains an insufficiency of lime; and this or a similar compound is most likely to be found in unskilfully made cement in which the proportions of lime, silica, and alumina are not present in correct combining weights, or when the temperature of burning is insufficiently high to induce the formation of those silicates and aluminates which constitute true Portland cement.

DISCUSSION.

Mr. D. B. Butler, Assoc.M.Inst.C.E., fully concurred that cement testing was a highly specialised skilled work. Aëration was not so necessary as it was some years ago; if cement would stand the British Standard Specification requirements as regards soundness, that was the rotary test, aëration was unnecessary. Absolute accuracy in the preparation of wire sieves, he believed, was almost impossible. The specific gravity test he considered practically of no worth. As regards the autoclave test, what was the good of subjecting cement to a high pressure of steam? The idea of testing cement for soundness, he thought, was to determine whether or not that cement would eventually expand or cause trouble in work. The boiling water test in nine cases out of ten was unnecessarily severe. The conditions of the setting and hardening of cement, the different conditions between hot water and cold water were quite different; and because a cement would expand in boiling water, it did not by any means follow that it was going to expand under other conditions. To enable a cement to pass the standard specification test, it had behoved manufacturers to greatly improve their methods of manufacture, and in that way indirectly it had immensely helped the British industry, but at the same time—it might be heresy to say so—he thought it was unnecessarily severe in the ordinary way. After all, the idea of a soundness test was one which would show them unsoundness, and not one which improved manufacture. The next point was free lime. Free lime in cement did not exist; he did not think it ever had. The cause of expansion of cement occasionally, which was much less frequent now than it used to be, was not free lime. Anyone who had tried to burn or to place lime at a higher temperature in juxtaposition with acid bases would find that it was impossible to prevent that lime from burning in places. His own theory as to the reason of expansion was that it was not free lime, but that it was a highly expansive lime compound of some kind, which very slowly hydrated, and expanded during hydration. He did not believe that free lime could exist in an ordinary Portland cement.

Mr. William G. Kirkaldy, Assoc.M.Inst.C.E., declared himself in favour of the Le Châtelier test, although some years ago he regarded it as too drastic.

Mr. Percival M. Fraser, as an architect, remarked that the main object of the Paper seemed to be to decry all known tests. The autoclave test seemed highly fantastic, but they must remember that the Le Châtelier test was considered a freak test when it came in. In regard to the testing in general, he was afraid his brother architects were satisfied with the tests that he was brought up on: filling a bottle full of cement at night, and if it did not either burst the bottle or act as a sort of small rattle next morning it was all right. He considered the crushing test should be developed and made a standard, as in time, he believed, it would replace the somewhat futile tensile test. In regard to the test sieve, he agreed that the expanded sieve was a very immature method, and he suggested the substitution of a perforated sheet.

Mr. W. G. Perkins, District Surveyor for Holborn, did not think there was anything in the Paper, with the exception of the boiling tests, and the question as to free lime, which would guide them as to the soundness of any cement that they might wish to use in their works. On the question of the sieves he agreed with all that had been said that evening. Some time ago they heard a good deal of a little instrument which was termed a "flourometer," by means of which those portions of cement which were ground to an impalpable powder were blown away from the coarser particles, and collected in a special vessel. Had that particular instrument been dropped?

If not, would not that be a better way of obtaining a perfectly fine cement, and so get something which was reliable on the score of fineness? He did not think there was much in the autoclave test, but the Le Châtelier method of testing cement he regarded as a good one. On the question of free lime, he thought they more often got free lime introduced into the cement on the works, either by the careless stirring of the cement in close proximity to a bin of lime, or they found it in the bricks or the tiles that were being used in conjunction with the cement.

Mr. J. N. N. Shillito urged that some time-limit should be fixed for the taking of samples after the cement had been delivered on the job.

Mr. W. A. Short asked Mr. Gadd to give them some rough outline of the course he pursued in testing the excellent cement which his firm turned out. Perhaps he might favour them with what he would suggest as an ideal form of cement testing. With regard to the question of sieves, possibly the National Physical Laboratory might be able to help them.

The President, in moving a vote of thanks to Mr. Gadd, said he should have liked to have seen, in regard to the tests, an analysis of the cement used, in order that they might, if possible, come to a definite conclusion as to the variation in the results. He had found a very good method for measuring and also for determining over large areas the variation in sieves was the use of the magic lantern. As the result of some experiments he made some years ago he found that if concrete were made simply with residues only, and kept in dry air, anything that would pass through a 160 sieve was absolutely useless. Briquettes made with a residue coarser than 160 were all blown, and that was due entirely to the gypsum. With reference to standard sand, he made his own from oolite or Portland stone, and he found that he got very much better results from sand that would pass through a 20 sieve, and be retained in a 30 than he could get with the ordinary Leighton Buzzard sand, and that was due entirely to the fact that all sand that came from Portland stone was extremely porous and crystalline, and that there was a locking action taking place between the cement and the stone. He got a very much more uniform result, especially in tension. He was pleased to see the high results Mr. Gadd got with an ordinary 4 to 1 concrete, where he had been using Kentish rock-stone. With a limestone, and especially the oolites, they would always get a very much greater strength in crushing resistance than they would with any of the smooth and the harder stones. Personally, he should like to see all neat cement tests done away with except as to soundness and setting time, so that they should rely entirely upon the 3 to 1 sands in tension and also in compression, and he thought that before long that would be adopted in this country, as was the case in Germany. The "flourometer" he considered was a very good thing for experimental purposes, but if one had to use a "flourometer" to get all the flour out of a ton of cement they would have to wait a very long time, and when they did get it it would be of very little value.

MR. LAURENCE GADD'S REPLY.

Mr. Gadd, in acknowledging the vote of thanks, replied to several of the observations which had been made in the course of the discussion. As to Mr. Butler's criticism on the aëration of samples, his point was this, that for the purpose of making a setting time test, aëration was not only unnecessary, but it was misleading. Aërating the small sample of cement upon which they were to make their test was subjecting that small sample to influences to which the bulk cement was not subjected. Whether cement contained gypsum or not, the effect of water and CO_2 respectively was all the same. Water would retard the setting time no matter whether there was gypsum present or not, and carbonic anhydride would accelerate the setting time. If some central authority could provide them with standard sieves, which were standard, it would be a very great convenience, and it would also be a very useful thing, if they could get an international sand, to people who were sending cement out all over the world. He came across many specimens of clinker which were quite brown, coffee-coloured, in fact, due to the reduction of iron salts, but he did not find that that clinker was any more unsound than the ordinary clinker. Mr. Percival Fraser was the speaker who gave him the greatest shock, when he said that the object of his Paper appeared to be to run down every test there was. That was not his object. The object of the Paper was to point out those parts of the test which, in his opinion, were faulty. He did not say do away with the tests, but if any portion of the test was misleading or faulty in any way, let them do away with the faulty part and improve it. He was further shocked by the suggestion that he decried crushing tests. He was very sorry if he gave Mr. Fraser that impression, because it was contrary to his view. He agreed that if they mixed sulphuric acid with the cement they would have a retardation of setting time just the same as if they added gypsum, but no acid got into the cement that he was experimenting with. Calcium sulphate in broken bricks or anything else in any quantity was about the worst thing they could mix with Portland cement. As to Mr. Shillito's suggestion, that was not a matter for him, as he did not represent the Standard Specification or the Specification Committee. With reference to Mr. Short's question, he was bound, like everybody else, by the Standard Specification. He made the tests according to the Standard Specification, but if Mr. Short asked him what tests did he rely upon for his own information and his own judgment, he relied principally upon the crushing tests; and he formed his opinion without the aid either of specific gravity or aeration. Several times he had tried to do away, or to find the means of doing away, with wire sieves. There was no doubt that if gypsum were added to cement, and it was not finely ground and equally distributed all over the cement, they might get little particles or nodules of gypsum, and where those occurred undoubtedly there was the nucleus of expansion, but that would take place in the cold, and it did not need boiling to bring it out. He agreed with the President in his hope that some day all neat tests would be abolished, and that they should rely entirely upon sand tests.

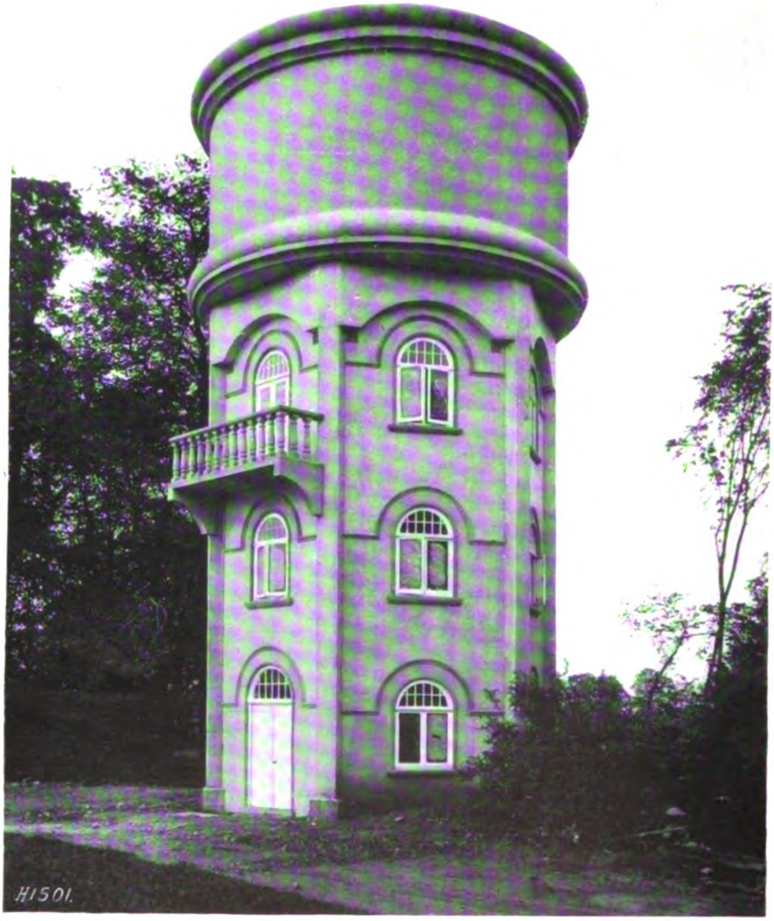
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE WATER TOWER NEAR BURTON-ON-TRENT.

THE water tower shown in our illustration has quite recently been erected entirely on the Coignet system of reinforced concrete at Rolleston-on-Dove, near Burton-on-Trent, for Sir Oswald Mosley, Bart. This water tower is in connection with the water supply for the village, the engineer for the work being Mr. John Frith, of Basloy, Derbyshire.



View of Completed Structure.
REINFORCED CONCRETE WATER TOWER, BURTON-ON-TRENT.

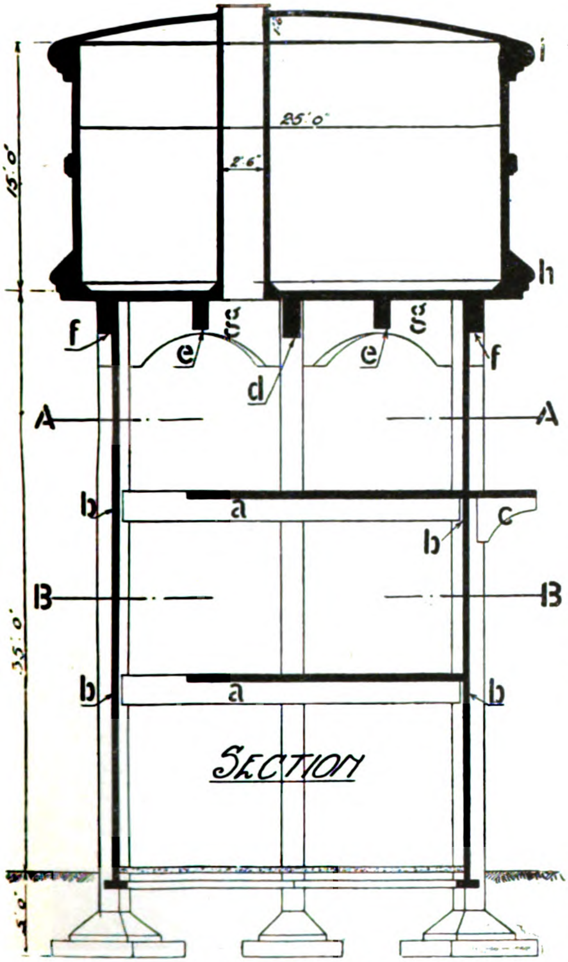
The tank has a capacity of 45,000 gallons, and is in the shape of a cylinder 15 ft. high and 25 ft. in diameter. The total height from the ground level to the top of the tower is 52 ft. The inside of the tower includes a first and second floor, and there is a balcony on second floor, as shown in the photograph. Access to the upper floors is given by means of a wooden staircase.

The water is forced into the tank by means of pumps, the inlet and overflow pipes being fixed inside the tower.

The work was carried out by the Derbyshire and Notts Coignet Contracting Co. (Messrs. Evans Bros.) of Alfreton, and the working drawings were prepared by Messrs. Edmond Coignet, Ltd., of 20, Victoria Street, Westminster, S.W.

The reinforcement is composed of round bars of mild steel supplied by Messrs. The Whitehead Iron and Steel Co., Ltd., Tredegar, Mon.

The tank was rendered on the inside with sand and cement and filled with water 14 days after the concreting operation was finished. A slight dampness appeared at first at the junction of the wall in the bottom, but, as usual in reinforced concrete water tanks, these signs disappeared after a few days.



Reinforced Concrete Water Tower, Burton-on-Trent.

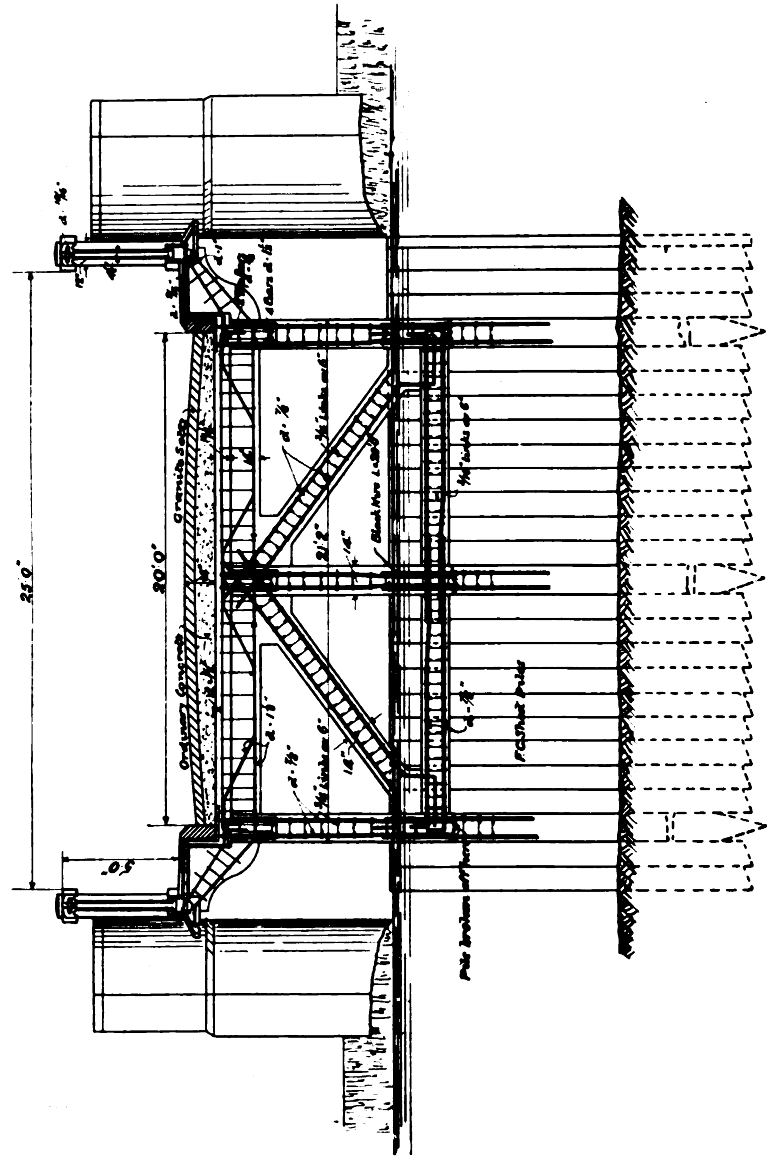
A REINFORCED CONCRETE BRIDGE AT WICKHAM MARKET, SUFFOLK.

The bridge over the River Deben at Wickham Market, Suffolk, which was partially destroyed by the floods in August, 1912, has recently been replaced by a new reinforced concrete structure designed by Mr. Henry Miller, M.Inst.C.E. (County Surveyor), in conjunction with Messrs. L. G. Mouchel and Partners, Ltd., of 38, Victoria Street, S.W.

The new bridge, which is constructed on the Hennebique system, has a span of 48 ft. clear of the abutments, and an overall width of 28 ft., as against 36 ft. and 26 ft. in the old bridge. The old brick abutments were taken completely away and new abutments in reinforced concrete constructed, 6 No. 14 in. by 14 in. piles, and 35 No. 6 in. by 12 in. sheet piles were driven on each side of the stream, the existing brick culverts under the approaches and the wing walls being retained.

The bridge is constructed in two spans, the central support consisting of 3 No. 14 in. by 14 in. piles, with 14 in. by 6 in. diagonal bracings and 14 in. by 8 in. horizontal cross bracings as shown in cross-section.

With regard to the reinforced concrete superstructure, the decking of the bridge is $7\frac{1}{2}$ in. thick, the main beams being 10 in. by 22 in. at 10 ft. centres, and the secondary beams 6 in. by 14 in. at 4 ft. centres, with a reinforced concrete parapet and coping as shown. The carriageway is 20 ft. wide, paved with granite setts on ordinary concrete, the thickness of the setts and concrete filling at the crown of the road being 14 in. and at the curbs 10 in. Footpaths, which are carried on reinforced concrete corbels at 4 ft. centres and finished in granolithic, are provided on each side of the bridge 2 ft. 6 in. wide, giving a total width between the copings of 25 ft.



Cross Section.

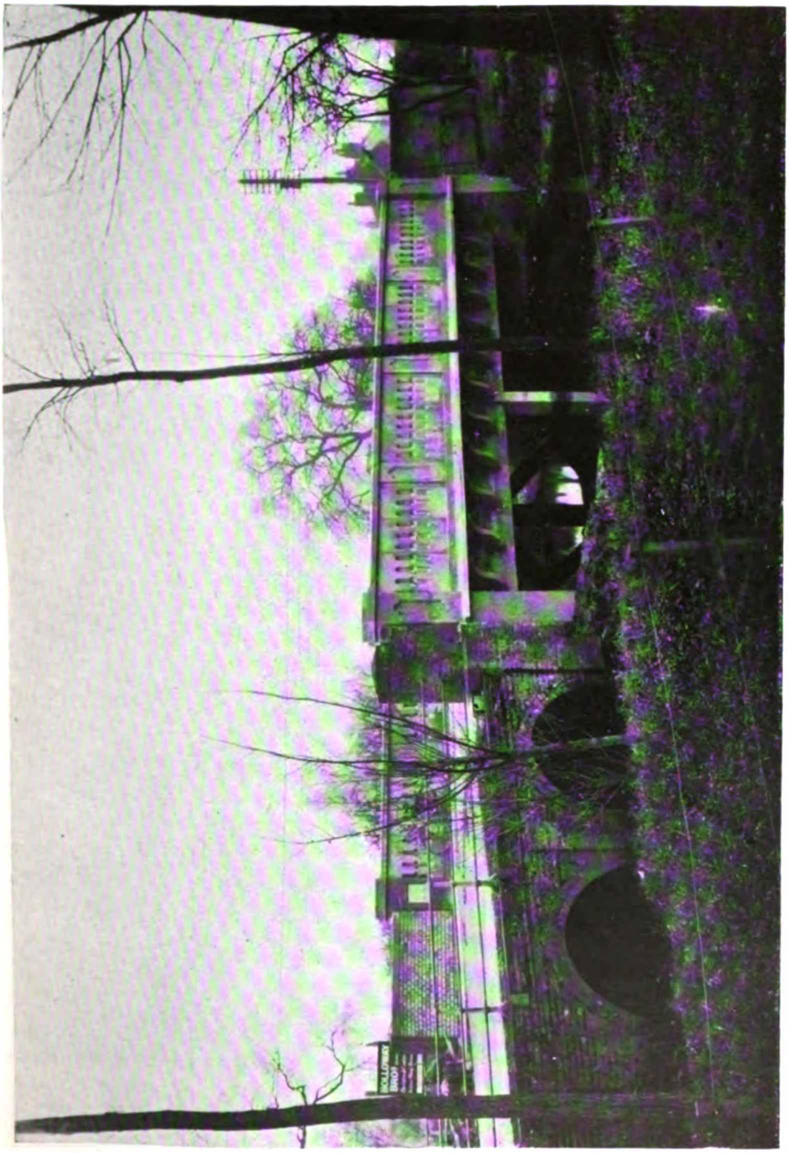
Reinforced Concrete Bridge at Wickham Market, Suffolk.

The new bridge, which has taken about six months to construct, was tested last December, and afterwards opened to traffic in the presence of a large representative company.

The contractors for the work were Messrs. Holloway Brothers (London), Ltd., Belvedere Road, Lambeth, S.E.

REINFORCED CONCRETE GASHOLDER TANK AT HAMBURG-FUHLSBÜTTEL.

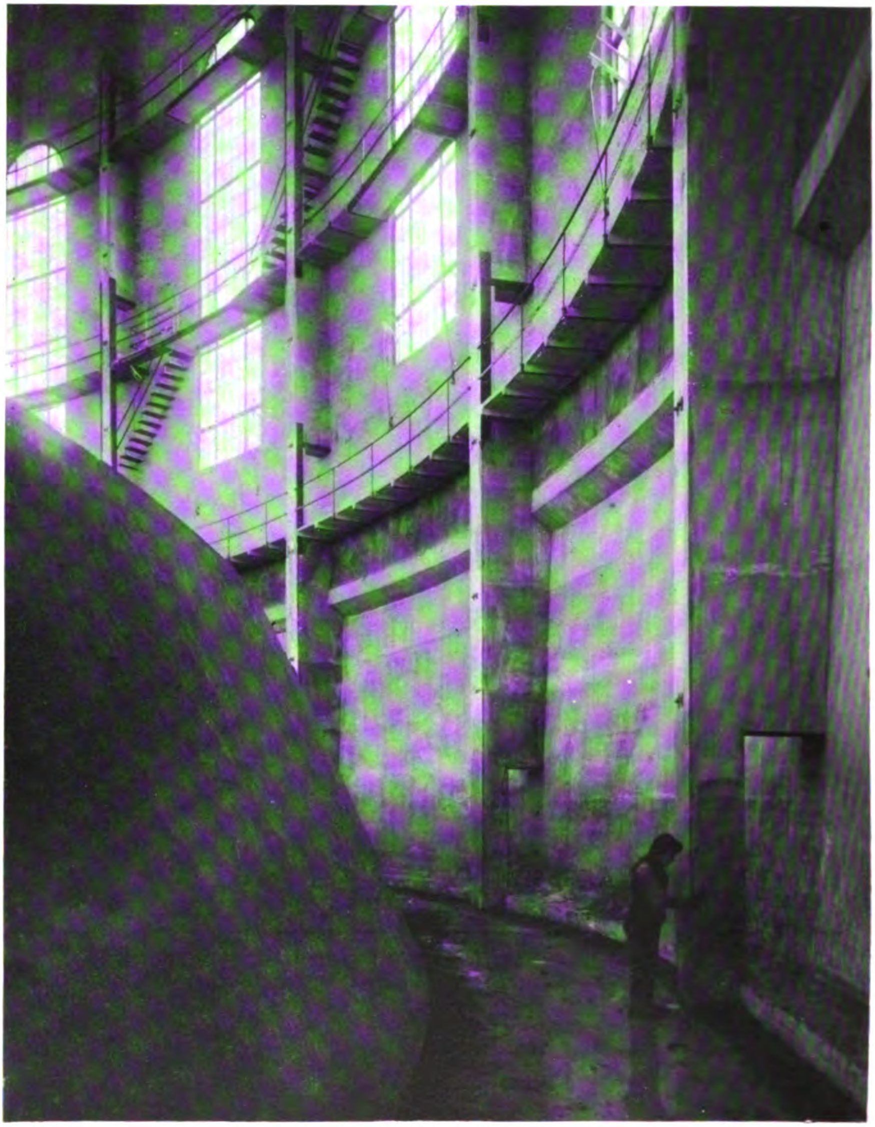
MESSRS. CHRISTIANI AND NIELSEN, of Copenhagen, have recently constructed the foundation and tank for a large gasholder in reinforced concrete, for the Gas Lighting Committee of Fuhlsbüttel. As the depth of water is 8 metres the containing ring is subjected to a bursting pressure due to that head of water, whilst the rigid connections at the base introduce considerable fixing moments. For the computation, therefore, the stresses in the ring due to these two causes are the determining factors. This involves a special method of computation, the triangular area which represents the hydrostatic pressure being divided in such a way that at every point the deformation due to the ring stress is equal to that due to the fixing moment.



View of Finished Bridge.

REINFORCED CONCRETE BRIDGE AT WICKHAM MARKET, SUFFOLK.

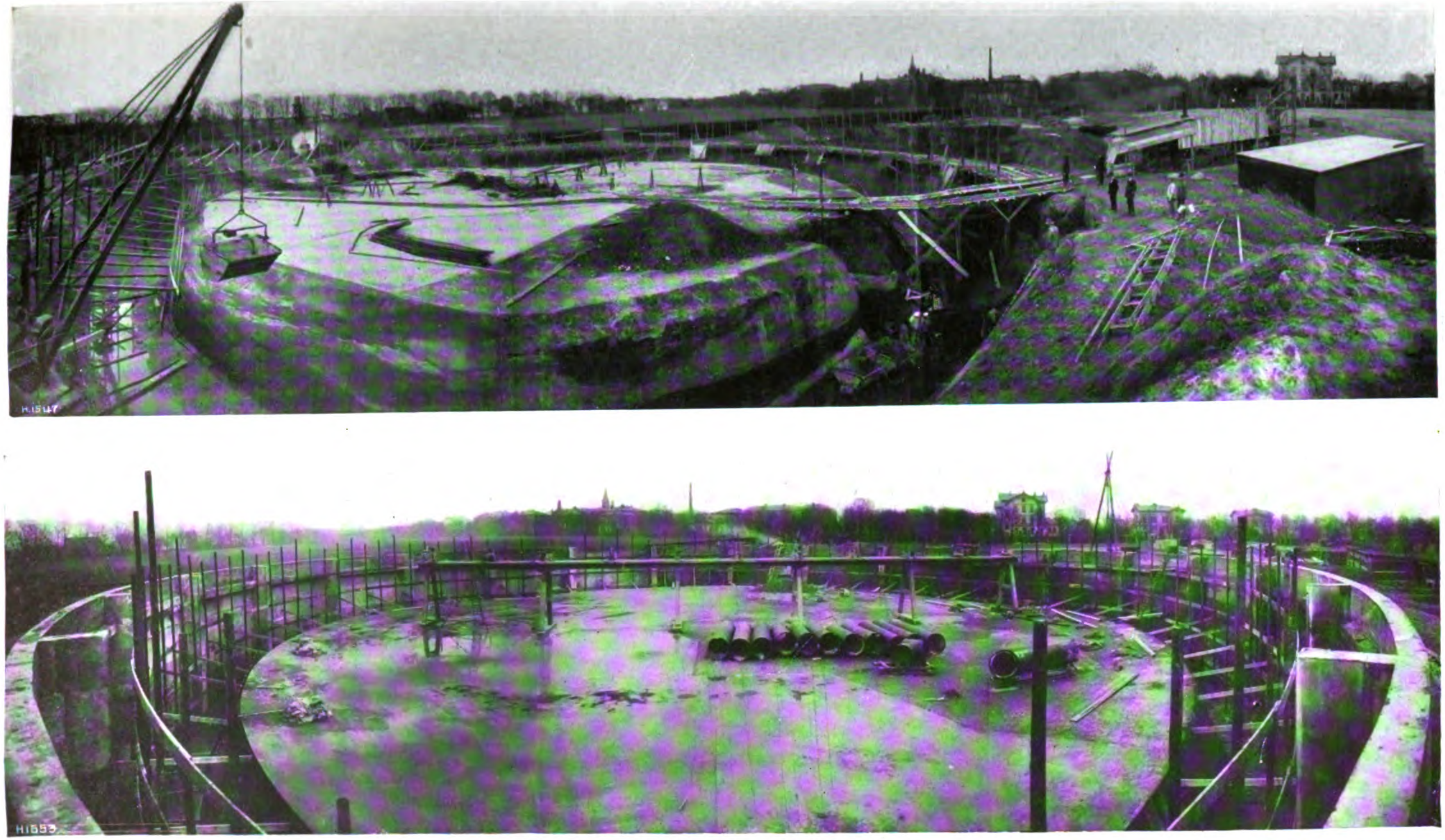
The internal diameter of the containing tank is 57·4 metres, the thickness of the outer wall increasing from 40 cm. at the top to 1 metre at the base. The inner wall of the containing tank slopes, forming a truncated cone, the top of which is the floor of the gasholder, a plate 20 cm. thick, reinforced with wire meshes, strengthened by 16 rings near to the outer edge. The base of the tank has a maximum thickness of 1 metre, diminishing outwards and inwards.



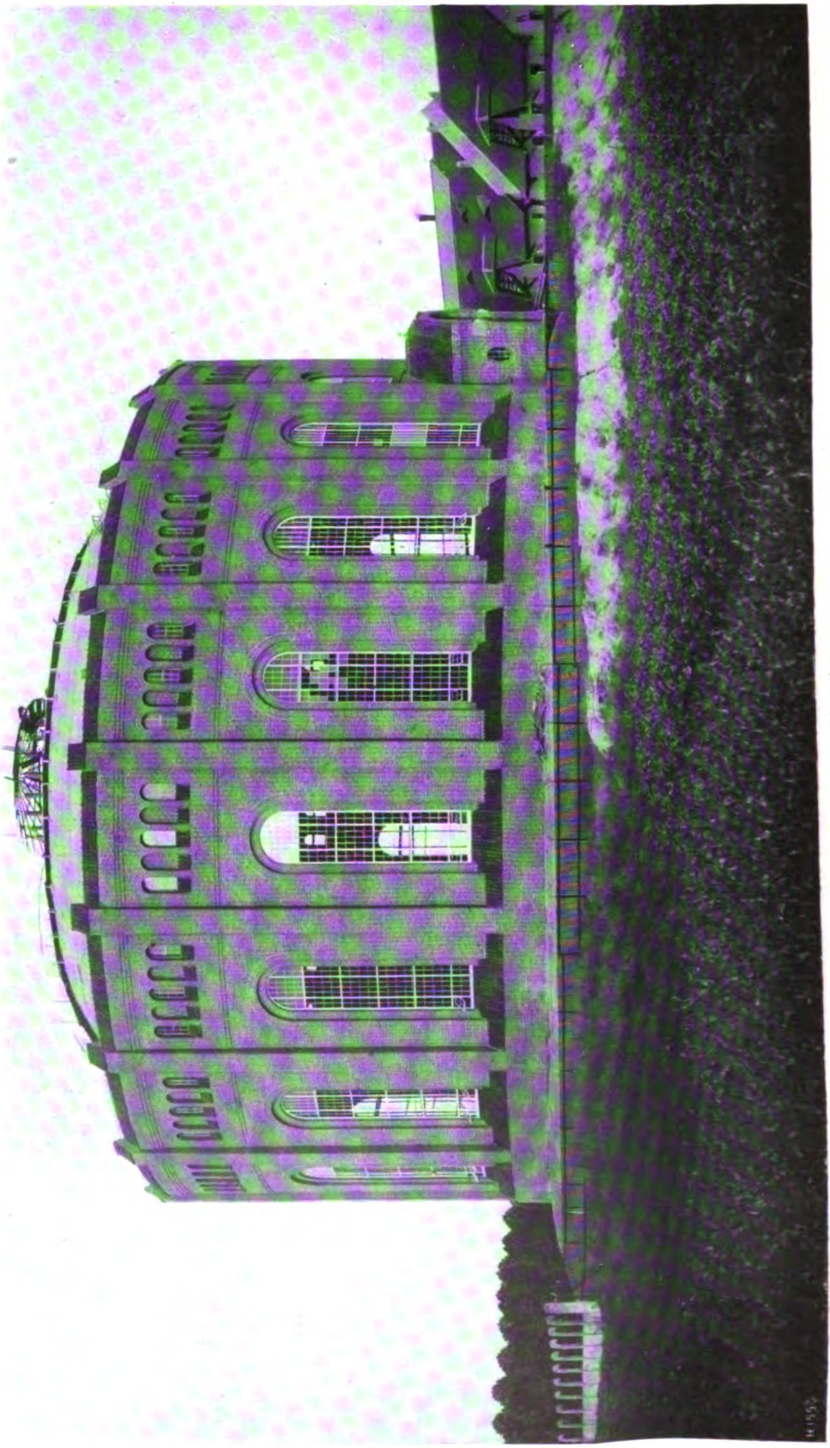
Interior View.
Reinforced Concrete Gasholder-Tank at Hamburg-Fuhlsbüttel.

FURTHER CONCRETE WORK AT TALBOT'S INCH, KILKENNY.

One of the latest additions to the many buildings erected in "Winget" blocks at Talbot's Inch, for the Kilkenny Woodworkers, under the auspices of the Right



Views showing Foundations in course of construction.
Reinforced Concrete Gasholder Tank at Hamburg-Fuhlsbüttel.

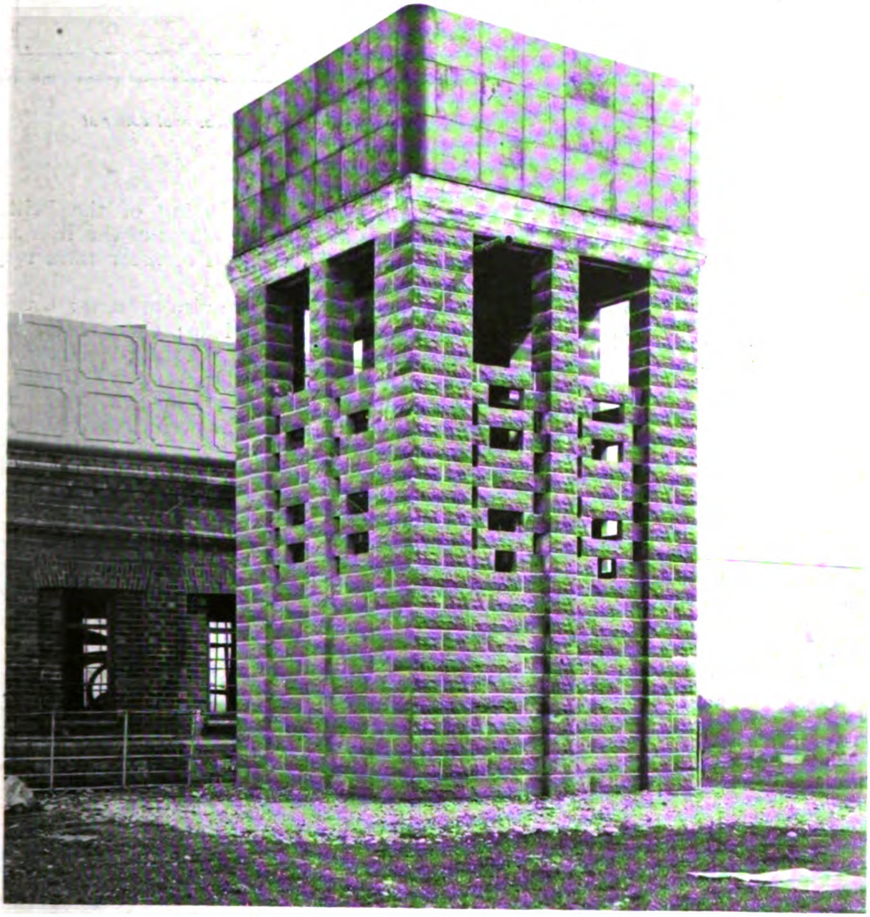


Exterior Elevation.

Reinforced Concrete Gasholder Tank at Hamburg-Fuhlsbüttel.

Honourable Ellen Countess Dowager of Desart, is here shown. The water tower carries the 7,500 gallon tank for the sprinkler installation in the woodworkers' factory, the base of same being 14 ft. by 14 ft., with a total height (including tank of 6 ft.) of just over 30 ft.

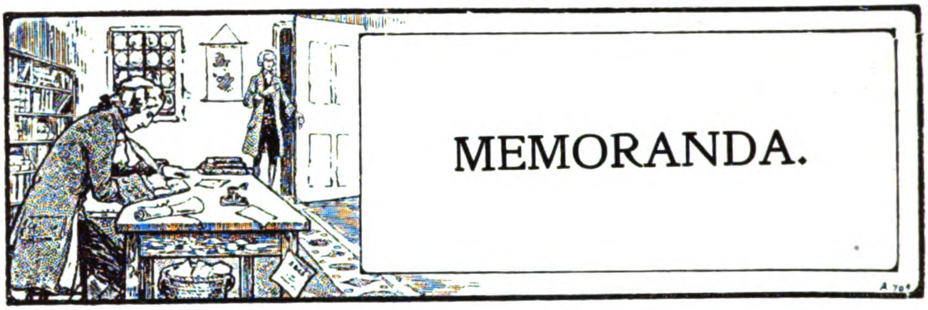
The "Winget" blocks used in the erection are double and single flue blocks, which are reinforced at the inner corners with $\frac{3}{8}$ in. bars, the inner space being filled in with rough concrete mixed 7 to 1.



Concrete Block Water Reservoir, Talbot's Inch, Kilkenny.

At the top of the tower for about 23 in. the girders are placed supporting the tank, all of which are encased in concrete.

The blocks were made by Messrs. The Concrete Block Co., of Talbot's Inch, and the whole of the work designed and carried out under the supervision of Mr. F. W. Kiddie, of Talbot's Inch.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

International Association for Testing Materials.—A meeting of the British Section of the International Testing Association was held at the offices of the Iron and Steel Institute, 28, Victoria Street, London, S.W., on Thursday, December 18th, 1913, at 4 p.m.

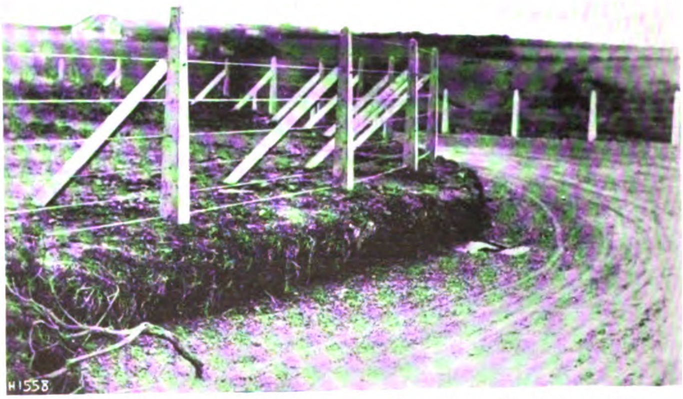
The chair was taken by Dr. W. C. Unwin, and there were also present: Dr. H. Borns; Mr. S. M. Dixon; Mr. F. W. Harbord; Mr. D. Heap; Colonel Herbert Hughes, C.B.; Mr. W. G. Kirkaldy; Mr. R. Lessing; Mr. G. C. Lloyd; Mr. J. T. Milton; Mr. H. Moore; Mr. L. S. Robertson; Dr. F. Rogers; Dr. Walter Rosenhain; Mr. E. H. Saniter; Mr. J. Cruickshank Smith; Mr. F. Tomlinson; Mr. Howard C. Wolfe. Letters of regret at their inability to be present were received from Sir H. F. Donaldson, K.C.B., Sir Robert Hadfield, F.R.S., Mr. E. O. Sachs, and others.

The draft scheme of organisation, drawn up by the provisional Committee of Management, was submitted to the meeting, and approved, subject to certain alterations.

The subject of the mode of dealing with such annual subventions from manufacturing firms, scientific and technical societies, institutions, and public bodies, as might from time to time be made, and of the question of representation of such bodies within the British Section, was referred to the Committee of Management.

On the motion of Mr. J. T. Milton, a cordial vote of thanks was unanimously passed to Dr. Unwin for presiding.

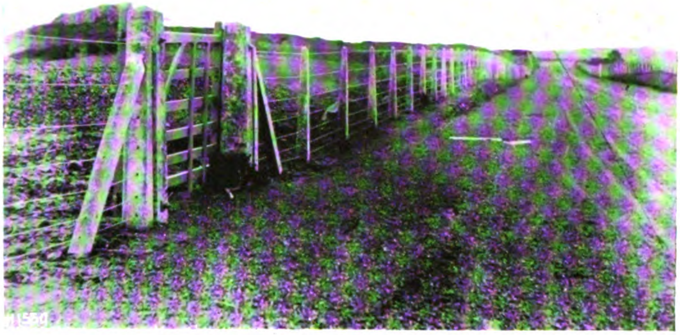
The Society of Engineers (Incorporated) Status Prize.—The Council of the Society of Engineers (Incorporated) may award in 1914 a premium of books or instruments to the value of £10 10s. for an approved essay on "The Status of the Engineering Profession." The Council reserve the right to withhold the premium if the essays received are



Reinforced Concrete Fence Posts at Dinas Way, Haverfordwest.

not of a sufficient standard of merit. The competition is open to all, but, before entering, application for detailed particulars should be made to the Secretary, 17, Victoria Street, Westminster. The last date for receiving essays is May 30th, 1914.

Reinforced Concrete Fence Posts for Dinas Way, Haverfordwest.—We reproduce herewith two photographs of some reinforced concrete work carried out in connection with the above new roads. This new route to Fishguard has recently been completed by the Pembrokeshire Borough Council. For a considerable distance it skirts along the high cliffs overlooking Fishguard Harbour, and then turns to the right overland. It is 2,600 ft. in length, with a carriageway of 20 ft. and a footpath of 4 ft. The boundary fences on the land side consist of reinforced concrete posts and wire strands. The engineer for this roadway was Mr. Arthur Thomas, of Haverfordwest, and the contractors were Messrs. Topham, Jones and Railton, of Westminster, London. The whole of the fence posts were manufactured and erected by the Reinforced Concrete Fence Posts, Ltd., of Broadway House, Westminster.



REINFORCED CONCRETE FENCE POSTS, DINAS WAY, HAVERFORDWEST.

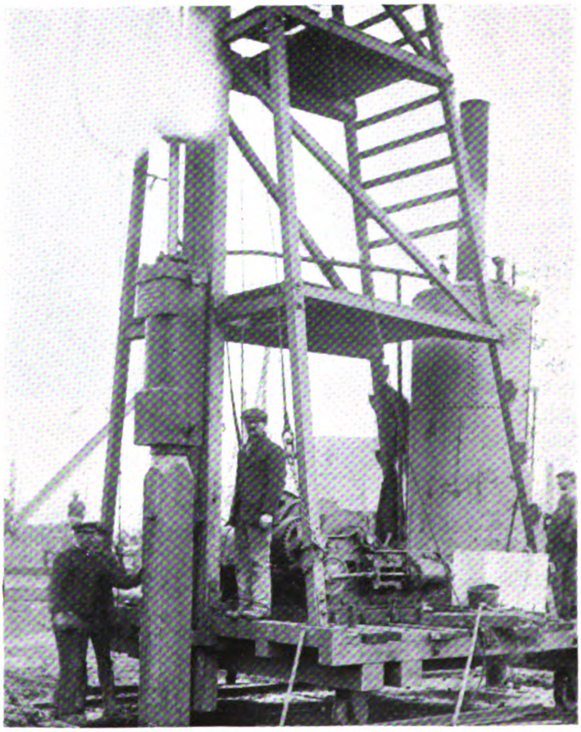
Reinforced Concrete Boat Ways, Rockhaven Harbour, N.D.—In a short article in the *Engineering News* Mr. S. R. Morrow gives some particulars of some reinforced concrete boatways constructed by the United States Government at Rockhaven Harbour, N.D. He states that the U.S. Engineer Office of Kansas City, Mo., has departed from the old practice of building such structures entirely of wood. Rockhaven Harbour is located on the west bank of the Missouri River about four miles above Mandan, N.D., and is the site of the repair plant for the fleet of Government vessels used in the control of the river. The new ways there, shown in the accompanying illustration, are of reinforced concrete with a timber "butter board" on top for the sliding plane.

There are ten ways, each 270 ft. long, the lower 130 ft. being on a 1 to $7\frac{1}{2}$ slope and the upper 140 ft. level. They are spaced 14 ft. centre to centre, and are supported on concrete columns 10 ft. centre to centre. The largest vessel for which they were designed is a steel-hulled boat 155 ft. long and 24 ft. beam.

The columns, with the exception of those at ends and top of slope, are 12 in. square and are placed to an average depth of 6 ft. in the ground. Where a good foundation was not struck at this depth an 8 in. post-hole auger was used in boring a hole to solid foundation. These holes were filled with concrete and were assumed to act as piling. With the exception of a few of the columns at the foot of the slope a good foundation of blue shale was generally struck at a depth of 6 ft. The columns were flared at bottom to 20 in. square, thereby increasing the bearing surface. As the earth had no tendency to cave, no forming was used underground excepting with the columns at water's edge, which were 4 ft. square and were built in the edge of a sand bar.

Each column was reinforced with four $\frac{5}{8}$ in. square twisted bars which were bent over and projected 2 ft. 2 in. into the beams. The aggregate used in concrete was a native gravel which contained sufficient sand and some dirt. On account of this dirt rich concrete was used, the mixture being 1 : 4. The water for concrete was pumped

PILE DRIVING PLANT



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CATALOGUES AND FIRM QUOTATIONS ON APPLICATION.

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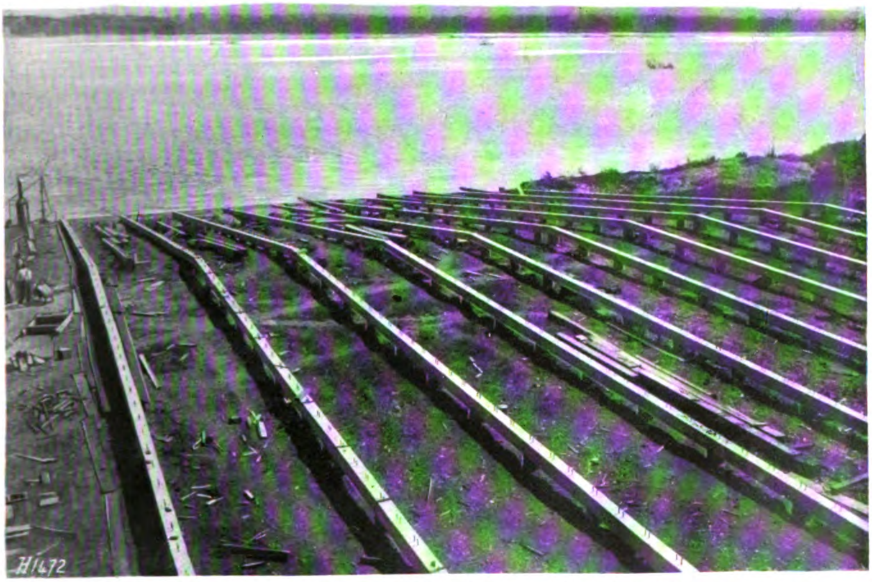
directly from the river to barrels at mixing platform by means of small plunger pump and hoist boiler. All concrete was mixed by hand and distributed in barrows.

The beams or ways proper, which are 12 by 14 in., were started after all columns were completed. The forms for these were made in two sides and bottom. One set of sides and two sets of bottoms were made for complete way, 270 ft. The bottoms were supported by clamps on the columns. The sides were also supported by these clamps. Hinged clamps were placed around the whole form, thus transferring part of the load from bottom to sides. The beams were allowed to set 24 hours with side forms in place, and from 48 to 96 hours with bottom forms in place. It took approximately 11 hours to concrete one beam 270 ft. long.

The beams were reinforced with two bent-up rods and two straight rods 2 in. from bottom. All rods were $\frac{5}{8}$ in. square twisted steel. At first no provision was made for temperature stresses, but a temperature crack appeared at the top of the slope in the first beam placed. This was partially overcome in succeeding beams by placing extra reinforcement in tops of beams.

The "butter boards" are 3 by 12 in. by 20 ft. fir sticks supported by 3 by 12 in. by 12 in. fir blocks, spaced 3 ft. 4 in. c. to c. Both blocks and "butter boards" are anchored to the concrete by means of $\frac{3}{4}$ by 11 in. machine bolts imbedded 7 in. in the concrete.



REINFORCED CONCRETE BOAT WAYS, ROCKHAVEN HARBOUR, U.S.A

Major Herbert Deakyne, Corps of Engineers, U.S.A., is the district officer for the Missouri River and tributaries. Fred W. Honens, Assistant Engineer, was in general charge of the work on the upper Missouri River, and Mr. Morrow was in local charge of the construction of the ways.

Concrete for Oil Tanks.—Experiments have been made to determine the availability of concrete for oil storage tanks, and it was found that the material was entirely suited for the purpose. Accordingly, a number of them have been built at El Paso, Texas, by one of the railroad companies of that section which is engaged in extensively handling oil from the fields of that State. Up to this time it was generally agreed that the presence of oil had some serious effect on the concrete, but if this is true it was not shown by the experiments.—*Concrete Age.*

Roof Construction on Concrete Building.—Whether the structural part shall be flat, and then covered with cinders to give a proper pitch for drainage, or whether the structural part, including the ceiling, shall be pitched and the fill avoided, is a point which may be discussed to advantage by engineers, in the opinion of Mr. L. C. Wason, President of the Aberthaw Construction Co., Boston, in a paper read before the Boston Society of Civil Engineers.

In construction the most serious objection to the first method is based on the lapse of time between the casting of the roof and the placing of the waterproof cover of tar and felt over the cinder fill. This usually permits a quantity of rain to collect in the cinder on top of the roof slab, which, while not absolutely watertight, will still hold a considerable quantity of water. In some cases holes have to be drilled through the ceiling to drain this slab. In one building water from this source dripped from the ceiling five months after the roof had been waterproofed. In another case there was some dripping even after two years.

CATALOGUES.

Fred Braby & Co., Ltd. — A new handbook has just been issued by this company, and it has been specially compiled for the use of architects and engineers. Illustrations are given of various buildings where the company's products have been used. The various tables as to weights, measures, currency, and calculations are a special feature of the book. The book will be forwarded on application to the company, at their offices, Petershill Road, Glasgow, or 110, Cannon Street, E.C.

CONTRACTS.

Bell's United Asbestos Co., Ltd., Southwark Street, S.E.—We are informed by Messrs. Bell that a notification has been issued by the War Office that this company's tender has been accepted for the supply, during the three years 1914, 1915, and 1916, of asbestos-cement (" Poilite ") roofing slates, wall and ceiling sheets, etc., made at the company's " Poilite " factory near London.

CHANGE OF ADDRESS.

Messrs. Geo. Sands and Son, Ltd., engineers and contractors, inform us that their London office has been removed from 37, Strand, W.C., to 31, Old Queen Street, Westminster, S.W. Telephone: Victoria 7854.

EDITORIAL MEMOS.

CONTRIBUTIONS.—Original contributions and illustrations are specially invited from engineers, architects, surveyors, chemists, and others engaged in practical or research work. MSS. should be written on one side of the paper only, giving full name and address of the author.

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DATES OF ISSUE.—This Journal is issued Monthly. For Advertisement Rates apply to Publisher. Matter for displayed advertisements required by 12th of month prior to subsequent issue, for Wants column by 18th.

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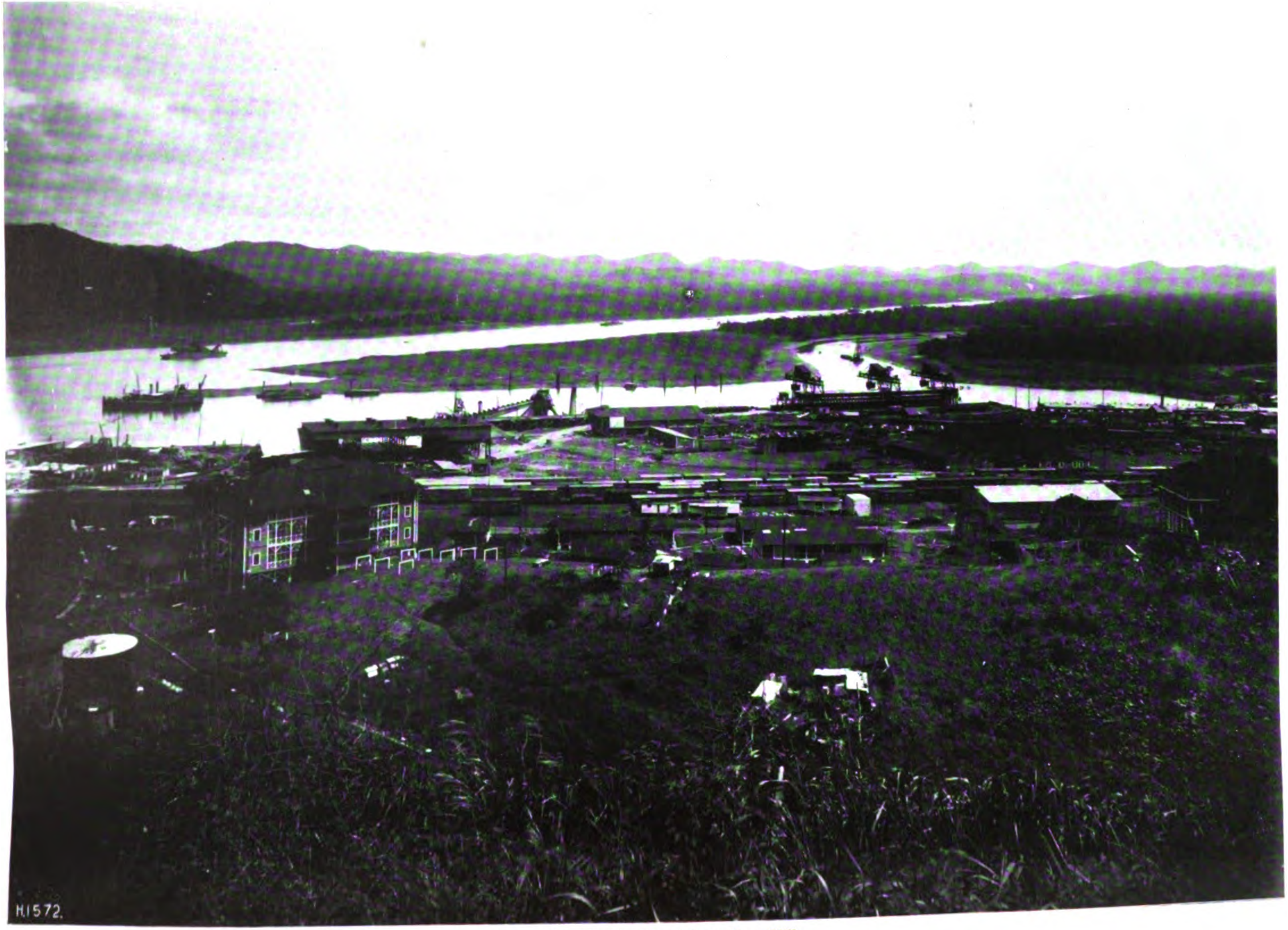


General View looking North from Sosa Hill
PACIFIC ENTRANCE TO THE PANAMA CANAL
(For description see ***page*** *149.)*

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume IX. No. 3. LONDON, MARCH, 1914.

EDITORIAL NOTES.

THE PANAMA CANAL.

A SERIES of articles dealing with some of the constructional features of the greatest of the world's great works in which concrete has played such an important part—viz., the Panama Canal—appeared in our Journal in 1911.

In this issue and a subsequent number we present two further articles, descriptive of other concrete and reinforced concrete work on the canal. Although the canal is not yet open for traffic, for all practical purposes the junction between the two great oceans has been formed, and it can only be a matter of months until regular traffic commences, and, as Mr. Leigh mentions in his article this month, "it is not unlikely that the canal will be in fit condition for trial navigation throughout its entire length within a few weeks after these words are in type."

Any examination of the plans or photographs of this gigantic undertaking must vividly impress the observer of the enormous rôle played by concrete and by Portland cement, more particularly in the construction of the immense locks whereby the difference of level, amounting to about 80 ft., is overcome. Rarely has Portland cement been applied with greater care. Everything that forethought and science could devise has been done to enable the material to be applied to the best advantage under the difficult circumstances of locality and climate.

That the Portland cement used was of American origin is only a matter of course; in fact, the undertaking was American in every sense of the word, and preferential use was made of national materials, even where there may have been some slight difference of price against the purchaser when the home product was compared with that of other countries. Would that we in this country were as commercially patriotic as the American nation always proves itself to be, and then we would not find large contracts going abroad on mere fractional differences of price, and irrespective of the national aspects of all home undertakings and of the difficulties of supervision.

At home, in our Colonies, and even in such spheres of influence as Egypt, there is all too great a tendency to ignore the national and economic aspects of placing orders at home, and some of our Colonies are notorious for this failing.

FIRE-RESISTANCE IN FACTORY CONSTRUCTION.

An excellent paper has recently been read before the Concrete Institute on "Factory Construction," the lecturer being Mr. Percival M. Fraser, A.R.I.B.A.

It would lead us too far to deal with the whole of the paper in this editorial, but we take one section entitled "The Fire-resisting Properties of Reinforced Concrete," as it claims special attention. We concur entirely with what Mr. Fraser indicates, that fire damage cannot be properly made good with insurance money where honest owners are concerned, having regard to the dislocation of business and its effect on the output of the firm, which, as a matter of fact, may never properly be recovered. Again, office documents cannot be replaced, skilled workmen thrown out of employment go elsewhere, and there is always the risk that a fire will be accompanied by loss of life.

Given a really well-considered design for reinforced concrete construction and the careful selection of suitable materials, nothing better can be utilised in factory construction than reinforced concrete from the fire point of view.

Mr. Fraser praises the rules of the fire insurance companies in the matter of reinforced concrete, and these rules were originally devised by a distinguished fire insurance surveyor, the late Mr. James Sheppard, who associated himself most actively with the tests with constructional materials undertaken by the British Fire Prevention Committee, and his influence generally upon the constructional rules of the insurance companies of the last 15 years was of the utmost importance. These rules have been excellent and have done immeasurable good, and in presenting Mr. Fraser's paper we have made a point of giving these rules in full.

If all reinforced concrete construction, even where it does not come under insurance tariff rates, were constructed to these particular rules no great harm could be done, and, as Mr. Fraser says, the absence of irritating detail is particularly welcome, and it should be an object lesson to the London County Council and the Local Government Board that these practical rules could be devised *ad hoc* some ten years back and do great service to the community, whilst the wise heads of these two authorities and the various professional societies concerned have been for some five years debating over details.

Our own view is that from the fire aspect it might have been well to exclude granite and granite chippings from the insurance specification, but obviously all such rules lend themselves to improvement, and when the next edition appears it might be well if some slight change were made in this direction.

STANDARD METHOD OF MEASUREMENT FOR REINFORCED CONCRETE.

In this issue we publish the draft report of the joint Committee of Representatives from the Quantity Surveyors' Association, the Quantity Surveyor members of the Concrete Institute, and the Reinforced Concrete Practice Standing Committee of the Concrete Institute on a Standard Method of Measurement for Reinforced Concrete; and we welcome this as an attempt to deal with a most important matter which, up to the present, has been quite neglected. There is every need to standardise some method of measurement, as the material has not been in general use for very many years, and, in fact, there are probably many Quantity Surveyors who have never prepared bills for reinforced concrete work, and in consequence they would be apt to proceed in such a manner that friction would arise with the contracting engineer in the process of settlement, and by the adoption of a standard method this could be avoided.

We do feel, however, that the method should be agreed to by the London Master Builders' Association, and, in fact, a mandatory report issued under the present circumstances would, in our opinion, be a mistake, and a recommendatory one would be preferable. The question as to whether the Concrete Institute represents professional engineers or contracting engineers is quite out of place, as the standard method suggested should be a fair one and involve the minimum amount of labour, consistent with a satisfactory result, for all parties concerned. The question of piles and pile-driving should most certainly be dealt with by the committee, as this cannot be considered to come under the heading of pillars. Also, why should not concrete pipes and other special features of this nature be included in order to cover every possible form of concrete work? Several interesting points were raised in the discussion, which we reprint in conjunction with the report, one of which was the question of taking out the centering for foundations in units of a square. Why should this not be billed in square yards, as the square foot is too small? The same might be applied to that for stairs, landings, and small floor slabs; and, in fact, to make it universal, this unit could be employed for all floor slabs, roofs, and walls. With regard to the term to be adopted for the centering or shuttering we consider the expression "False Work" would meet the requirements and apply to all timbering, whether in the form of plain shuttering or temporary props.

We hope that these points will be considered by the committee before the report is adopted and circulated.

CONCRETE COTTAGE COMPETITION.

We have received various questions from would-be competitors in respect of the above competition, and we are issuing a printed slip to each competitor who has applied direct to the office of this journal for the Competition Conditions, setting out the questions we have received and the answers that have been given.

CLAUSE 3.—Quite a number of questions have reached us regarding this clause. Various competitors have asked whether—

(*a*) *Each* cottage is to have a frontage of 65 ft. or whether a series of six cottages will have a frontage of 65 ft.

(*b*) Is it optional to treat the six cottages as *all in one block?*

Answer.—(a) There are *six* plots adjoining one another, *each* plot is taken at an area of 65 ft. frontage by 200 ft. depth, or, in other words, 65 ft. frontage for each cottage or 130 ft. per pair of cottages.

(*b*) It is not optional to treat the six cottages in one block. The competition is for suitable detached or semi-detached cottages, and at the most one pair of cottages could share a boundary line.

CLAUSE 5b.—Is it necessary for cottages to have both a front and back entrance?

Answer.—It is not necessary for the cottages to have a front and back entrance, but whether only a front entrance be given or both, the entrance must in either case be an *indirect* entrance whether it be to the living room or to the kitchen. In other words, no *direct* entrance to any living room is permitted.

CLAUSE 10.—(*a*) Must beds for the inmates be shown as separate single beds, or are ordinary double beds 6 ft. by 4 ft. 6 in. allowable?

(*b*) Beds 6 ft. by 2 ft. 9 in. are given for adults and 5 ft. 6 in. by 2 ft. 6 in. for each child. Would it not be better that the dimensions be 6 ft. 6 in. by 4 ft. 6 in. for adults, and 6 ft. by 4 ft. for children?

Answer.—(*a*) Single beds must be shown, not double beds.

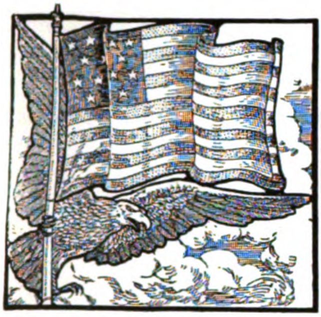
(*b*) The sizes for the beds must be strictly adhered to.

CLAUSE 14.—Will a copy of the cubing figures satisfy the requirements for page 5 of descriptive specification?

Answer.—A statement must be given by the competitor, beyond the simple cubing figures, as to how he himself has arrived at the cost, data, measurements, etc.

PRICES OF MATERIALS AND CARTAGE.—A number of competitors have asked whether a schedule of prices is issued as to the cost of materials, such as cement, sand, gravel, etc., and the cost of cartage.

Answer.—It is not intended to issue a schedule of prices; it is left to competitors to use their own discretion in this respect.



CONCRETE MASONRY IN THE PANAMA CANAL.

I.

By JOHN GEO. LEIGH.

In 1911 this journal published a series of articles on the Panama Canal, but since the publication of those articles, much additional concrete work has been carried out, and we are therefore publishing two further articles on this great work.—ED.

For the expeditious completion and relatively economical construction of the Panama Canal, the people of the United States are indebted in no small measure to a judgment delivered by President Roosevelt on February 19th, 1906. During the years which had elapsed since Congress authorised the acquisition of the rights and property of the second French Canal Company there had developed in the United States a strong movement in favour of the completion of the enterprise as a highway at sea level. With a view to closing this unwelcome controversy and so enable the workers on the Canal to pursue their operations and studies to indubitably useful and well-defined ends, the President convened a Board of Consulting Engineers, consisting of nine Americans, a high official of the Suez Canal, and four experts nominated by the British, French, German and Netherlands Governments, to consider and report upon the various plans proposed to and by the then existing Canal Commission. This Board, as arranged, met at Washington, subsequently proceeded to the Isthmus, and in due course presented to the Commission majority and minority reports. These, in turn, were considered by the Commission, with the result that there were found in favour of a sea-level canal a majority—eight in number, including the five foreign members—of the Board of Consulting Engineers and one member of the Canal Commission; while five of the eight American members of the Board and a corresponding number of the members of the Canal Commission, together with the latter's chief engineer and Mr. Taft, then Secretary of War, strongly supported the construction of a canal with locks. It was after careful study of the various papers embodying these divergent views and exhaustive consideration of the whole subject that President Roosevelt, on the date mentioned, transmitted to Congress a recommendation that the Canal should be built on substantially the plan outlined by the majority of his American advisers.

There can to-day be no question as to the wisdom and foresight shown by President Roosevelt on this occasion. As he pointed out in his Message to Congress, there appeared every likelihood that a high level canal with locks would not cost more than half as much and might be built in half the time, that the risk connected with its construction would be less, that for large ships the transit would be more rapid, and that, taking all the circumstances into account, the actual cost of maintenance would be less. Concerning the prophecies of disaster in which the majority of the Board of Consulting Engineers had indulged, he said little, contenting himself with the remark that they appeared to be vitiated by failure to pay proper heed to the lessons taught by the construction and operation of the Sault Ste. Marie Canal, the great traffic canal of the New World, which, although closed to navigation during the winter months, carries annually three times the traffic of the sea-level Suez Canal. He might have added, in the same connection, that insufficient regard had been devoted to the merits as constructional materials of concrete and reinforced concrete.

EXPERT ERRORS.

Speaking generally, it may be said that work on the Isthmus has been divided into two parts—destructive and constructive, and that it is upon completion of the first, and not the second, that depends the date when the great highway will be available for the use of the commerce and navies of the world. Well within, and frequently considerably in advance of, the estimates of time required for their completion, the locks and other massive structures, together with the wonderful installations of operating machinery hidden in their walls, are virtually ready for service. That the same cannot be said of the highway as a whole is due to miscalculations of possible difficulties and dangers not less remarkable than those to which reference has been made.

The amount of excavation required to complete a navigable channel across the Isthmus has greatly exceeded expert anticipations. The minority report of the Board of Consulting Engineers in 1906 estimated the total excavation necessary for a canal with a summit level of 85 ft. at 95,955,000 cub. yards, of which 53,765,000 cub. yards would be taken from the Culebra Cut; and the majority report of the same Board held that for a sea-level canal with a depth of 40 ft. the corresponding requirements would be 231,026,477 cub. yards and 109,891,710 cub. yards. To show how deceptive were these estimates it is sufficient to note that at the close of last year the material already removed from the Cut, or awaiting dredging, was double the amount originally estimated for the entire Canal and 22,000,000 cub. yards greater than the revised and more careful estimate of 1908. This increase has been due partially to the widening of the bottom of the channel in the Culebra section from 200 ft. to 300 ft. and to other enlargements of the original plan. Primarily, however, it is the result of the additional excavation of over 25,000,000 cub. yards consequent upon the development of slides and breaks in the banks of the Canal prism in the Culebra Cut. To meet the contingency of such cavings-in, the international experts in 1906 made what they no doubt considered the generous allowance of 500,000 cub. yards! Happily, at the moment of writing, the Cut has been almost wholly cleared, and there appears every reason to believe that the slides have reached the angle of repose and will, hereafter, give little trouble. This being so, it is not unlikely that the Canal will be in fit condition for trial navigation throughout its entire length within a few weeks after these words are in type.

Under these circumstances, it seems opportune to recall the series of articles devoted to features of constructional work likely to prove of special

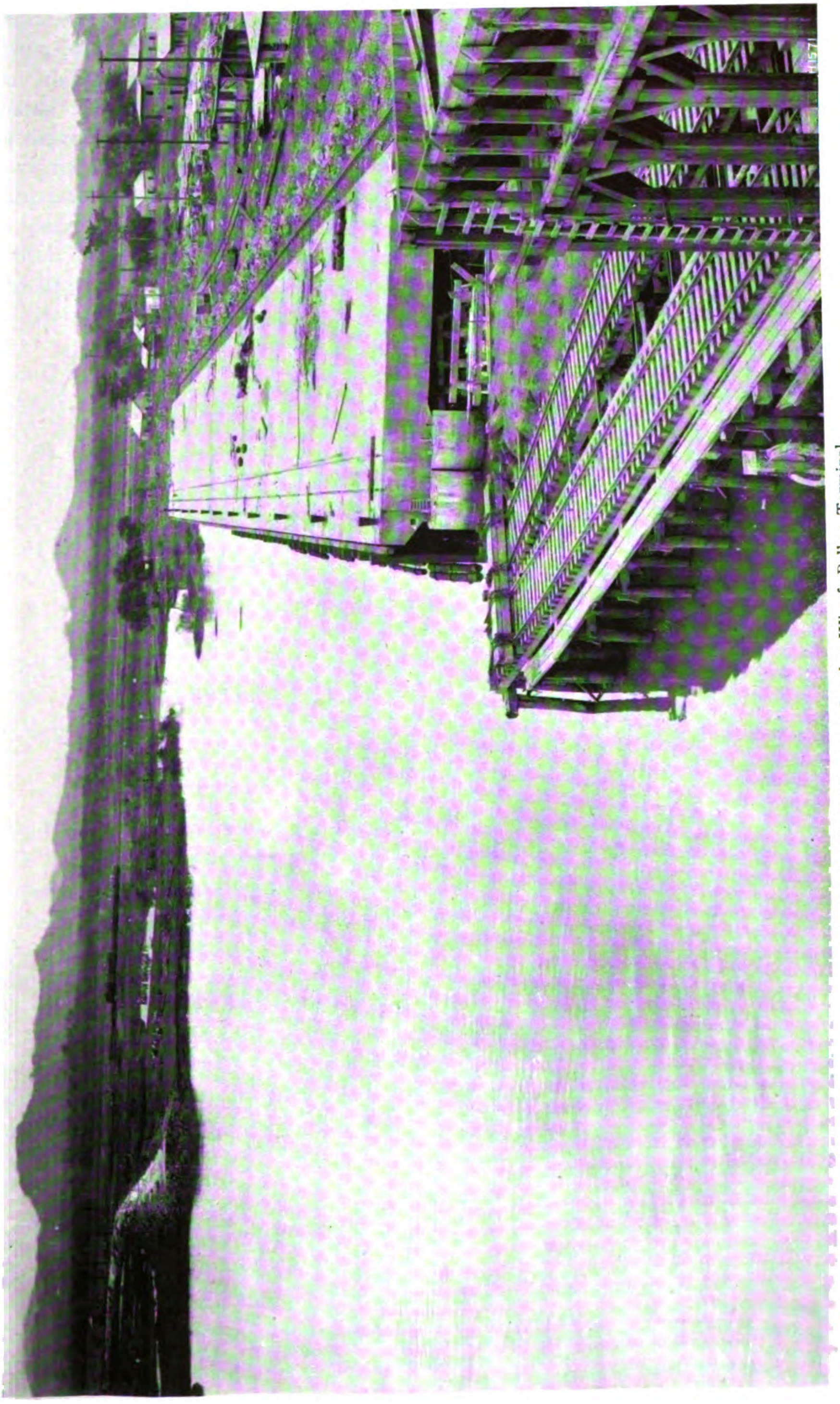


Fig. 1. Reinforced Concrete Lumber Wharf, Balboa Terminal.

Concrete Masonry in the Panama Canal.

interest to readers of this journal which it was my privilege to contribute to the pages of the latter some three years ago.* All the more important structures and installations of operating machinery to which attention was devoted in these articles have been completed, with results so satisfactory that there has been no hesitation in any quarter in commending the judgment of those to whose advocacy of concrete as a building material may be ascribed much of the success and economy of this side of canal construction. Referring to the locks, it may be noted that, at Gatun, owing to the greater depth of the foundations deemed desirable for the approach walls, and at Pedro Miguel and Miraflores, for various reasons, the estimates of concrete required have been subjected to the following revisions:—

	1910. Cub. yds.	1912. Cub. yds.
Gatun Locks	2,000,000	2,050,000
Pedro Miguel	837,400	890,750
Miraflores	1,362,000	1,412,736

The actual amounts placed in the several locks and auxiliary works up to January 1st of this year were:—

	Cub. yds.
Gatun locks	2,068,089
Gatun spillway	231,410
Hydro-electric station	7,167
Gatun control house, ducts, etc.	2,993
Pedro Miguel locks	923,438
Miraflores locks	1,500,525
Miraflores spillway	79,004
Pedro Miguel-Miraflores duct line	6,193

Not the least remarkable circumstance associated with the building of the locks has been the expedition with which the work has been accomplished. The placing of concrete began at Gatun on August 24th, 1909; at Pedro Miguel on September 1st of the same year, and at Miraflores, with the exception of 102 cub. yards laid in July and August, 1909, and 500 cub. yards placed during February to May following, in June, 1910. Yet all the mass masonry at Gatun locks—the largest concrete structure in the world—as well as at Miraflores was completed before the end of May, 1913, while that at Pedro Miguel was finished several months earlier. Subsequent work, for which, generally speaking, only portable mixers were requisitioned, has consisted of relatively small operations around machinery, etc. The auxiliary plant of two 2-cub. yard mixers, which had been in service about twenty-seven months east of the upper approach to Gatun locks, was closed on March 11th, 1912, and on August 16th, 1913, the dismantlement was begun of the large installation on the west side of the locks known as plant No. 1, a description of which, with its electric services from the stock piles and to the cableways, appeared in CONCRETE AND CONSTRUCTIONAL ENGINEERING of May, 1911. This plant during its four years' service had mixed over 1,600,000 cub. yards of concrete. A third large plant, equipped with two 2-cub. yard mixers, remained in use a few months longer, but for the completion of the hydro-electric power house two ½-cub. yard portable mixers have been used. The two berm and four chamber cranes, of which illustrated descriptions were given in this journal of June, 1912, employed at Pedro Miguel from April, 1910, were transferred to and placed in service at Miraflores between April, 1911, and March 26th, 1912; and, with other berm cranes, used first at Miraflores, were finally dismantled after July of last year.

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* "Concrete Construction in the Panama Canal." CONCRETE AND CONSTRUCTIONAL ENGINEERING, May, June, and August, 1911.

ATLANTIC TERMINAL DOCKS.

Concrete will figure very prominently in the construction of the docks at the Atlantic entrance of the Canal and of the more extensive terminal facilities

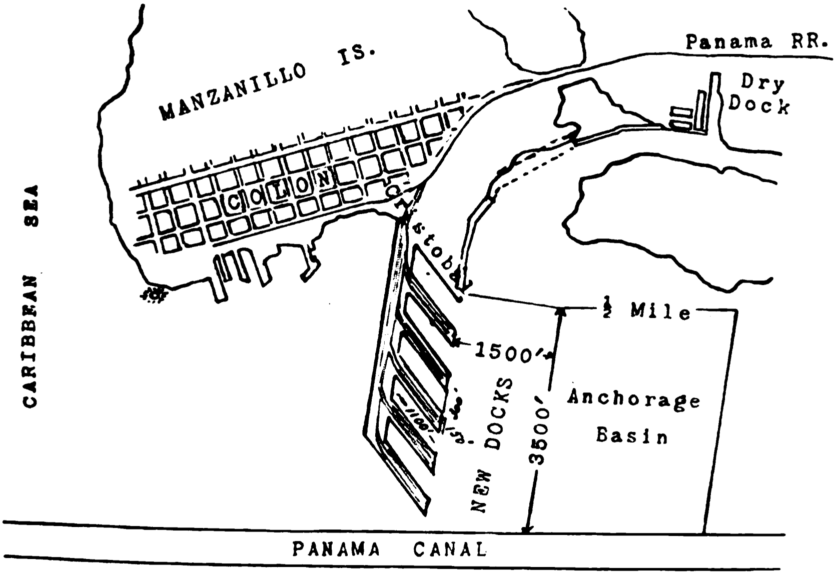


Fig. 2. Dock Accommodation at Cristobal.
Concrete Masonry in the Panama Canal.

planned at the Pacific end. As will be seen from the accompanying illustration (*Fig. 2*), the docks and anchorage basin provided and contemplated south of Colon will enable vessels to discharge and take on cargo without entering the Canal itself. The preliminary borings at the site having indicated a good bottom, it was decided to adopt the method of concrete bulkhead construction. In the case of the works already completed or in hand, steel cylinders 10 ft. in diameter and spaced 20 ft. from centre to centre, were sunk to bed rock, then filled with concrete and connected by a solid bulkhead of reinforced concrete sheet piles, 12 in. by 20 in., driven to a point 15 ft. below the lowest dredging of the channel. A steel girder encased in concrete, joining the tops of these cylinders, and a 24-in. I beam, similarly encased and placed 15 ft. below the water line, take the thrust of the piling. The cylinders are tied together in pairs directly across the width of each pier, and the area with bulkheads are filled to floor level, 10 ft. above mean tide, and covered with a floor of surface-hardened concrete having a total sustaining capacity, including live and dead loads, of 1,000 lb. to the sq. ft. The project provides for two docks or quay walls on Cristobal Point and for a number of piers jutting into the ship basin from a mole. For the present, however, only the two docks, a part of the mole and one pier have been constructed, the remainder of the work being left for execution as need for it may develop. The docks are 426 ft. and 1,042 ft. long and 209 ft. wide, while the pier has a length of 1,100 ft. and a width of 75 ft. 6 in. The dock superstructure is entirely fireproof, the walls being of reinforced concrete, 5 in. thick, and the roof of concrete slabs, reinforced with expanded metal. In the superstructure there have also been used about 350 tons of steel. For other parts of the work there have been, or will be, required 675 steel cylinders, 152,565 cub. yards of concrete, 402,000 lin. ft. of reinforced concrete sheet piling, 1,500,000 lb. of steel girder and about 800,000 lb. of steel I beam.

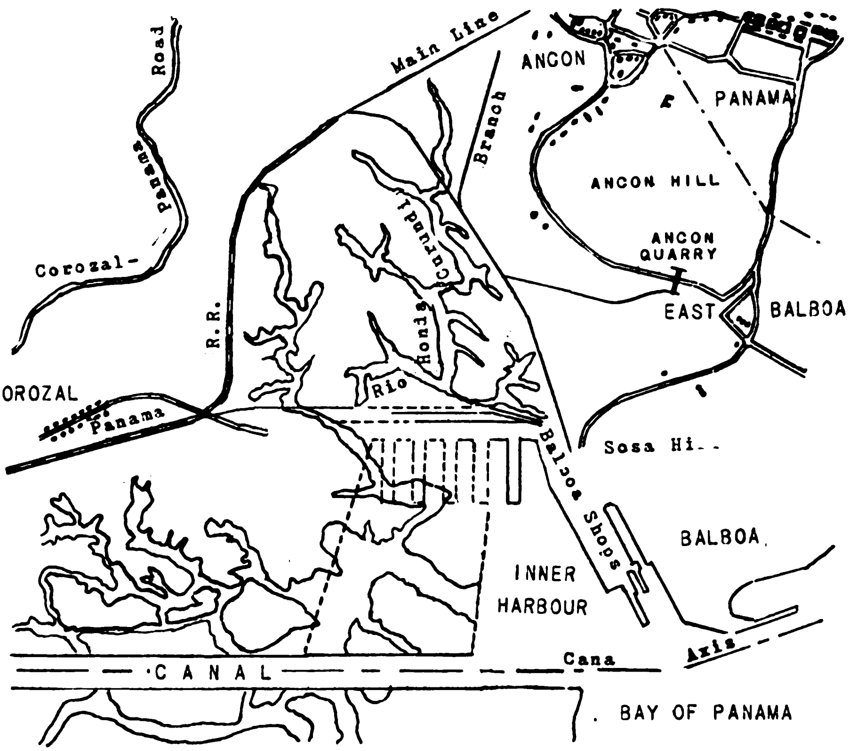


Fig. 3. Reclaimed Land at the Pacific Entrance. The area bounded by the main line and the Balboa branch of the Panama Railroad has been reclaimed by hydraulic filling. See also *Frontispiece*.

CONCRETE MASONRY IN THE PANAMA CANAL.

THE NEW PORT AND TOWN OF BALBOA.

The frontispiece in the present issue of CONCRETE AND CONSTRUCTIONAL ENGINEERING is a view of the Pacific entrance to the Canal and of the site of the port and town of Balboa now in course of construction. As evidenced by this photograph and, in fuller detail, by *Fig.* 3, much of the land immediately east of the railway yard which is to be built along the inner ends of the piers designed to bound one side of the future harbour is reclaimed swamp, formerly extending from the Balboa branch of the Panama Railroad to the main line. It covered an area of 400 acres, and about 5,000,000 cub. yards of material have been used in raising its surface 15 ft. above mean sea level. For extending the inner harbour to its ultimate proposed dimensions other swamp land will require to be dredged.

Work on the reinforced concrete lumber wharf, or pier No. 1 (see *Figs.* 1 and 8), the first of the permanent improvements taken in hand in the harbour at the Pacific end of the Canal, was commenced in February, 1911. Essential features of this erection, the superstructure of which was begun on December 2nd, 1911, and completed in little more than two months, are (*a*) two rows, 35 ft. apart, of solid concrete caissons, 50 in number, 8 ft. in outside diameter, and placed on 30 ft. centres; (*b*) main girders, resting on every set of caissons and extending the width of the wharf, 55 ft.; (*c*) eight axial beams, bridging the spaces between the main girders and heavily reinforced at their junctures with the latter, and (*d*) on these supports a concrete floor, 6 in. thick.

The tops of the caissons are 10 ft. above mean sea level, and the surface of the floor at elevation + 17. The concrete filling for the caissons, which was reinforced from ground rock to top with four double rows of old French rails connected by fishplates, is continued into the forms for the main girders, the latter and the caissons being thus set monolithically. The ends of each girder are embedded in a block of concrete 5 ft. wide at the bottom, where they join the caisson filling, the rectangular cross-section in the parts projecting beyond the caissons being 2 ft. 6 in. thick and 4 ft. 8 in. deep. This is reinforced with 16 bars of 1 in. and 1¾ in. twisted steel, enclosed in stirrups of twisted ½ in. bars.

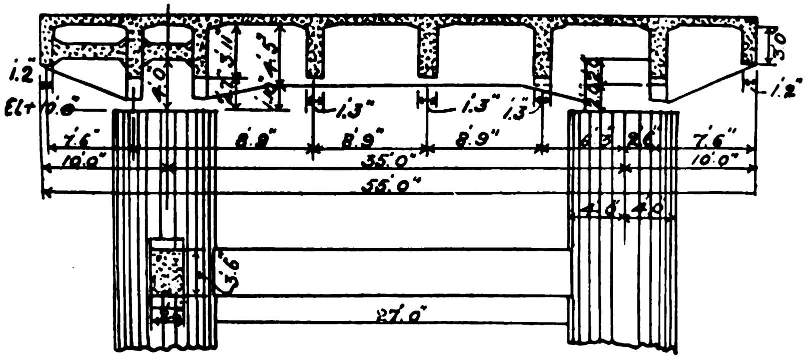


Fig. 4. Cross- ection between Piers, Balboa Lumber Wharf.
CONCRETE MASONRY IN THE PANAMA CANAL.

In the following sketch, *Fig.* 7, is shown the juncture of a girder with a caisson. On the water side of the wharf runs a railway, directly over the outer row of caissons. All beams, except the two at the wharf edges, are 15 in. thick and 3 ft. 9 in. deep, the edge beams being 14 in. thick and 3 ft. deep. The

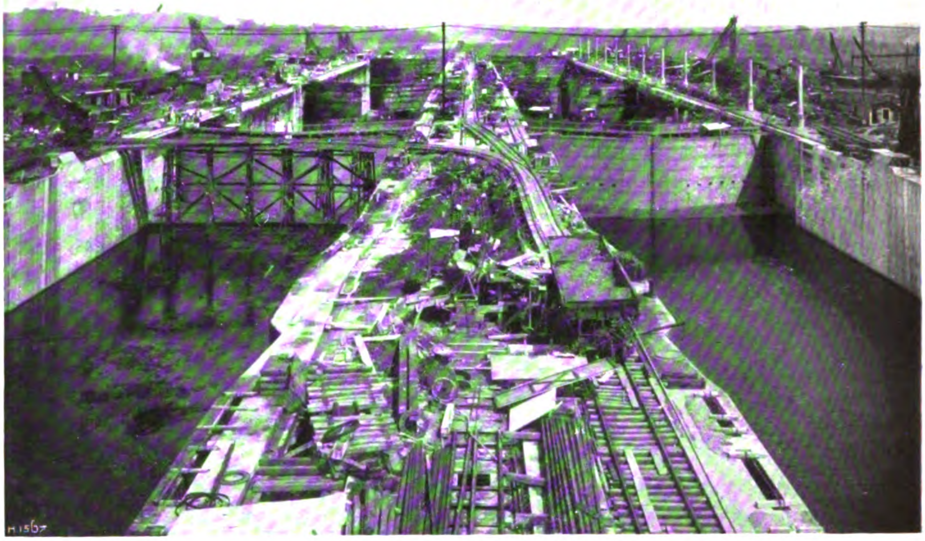


Fig. 5. Gatun Upper Locks. Looking North from the Lighthouse on Centre Wall.

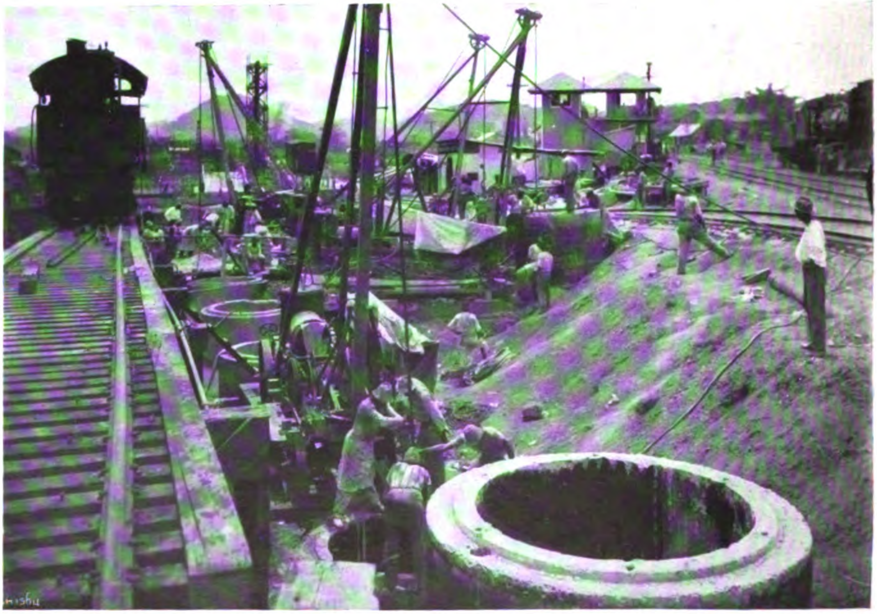


Fig. 6. Sinking Caissons for Foundations, Miraflores Upper Locks. Construction of North Approach Wall.

CONCRETE MASONRY IN THE PANAMA CANAL.

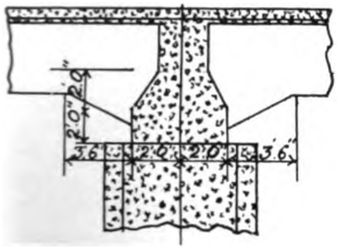


Fig. 7. Juncture of Girder with Caisson, Balboa Lumber Wharf.

Concrete Masonry in the Panama Canal.

main reinforcement in the middle of each beam consists of eight 1-in. twisted bars, with stirrups of ¾ in. twist placed about every 18 in., and the rail beams have, as additional reinforcement at the junction with the main girder, two 1¼-in. twisted bars, extending into the girder from each side, or four at each caisson.

Four feet below mean sea level, or 14 ft. below the tops of the caissons, the caissons of the outer row are joined together with tie girders, and at the same elevation a tie girder extends from the caisson across to its mate of the inner row. These tie girders are 2 ft. deep and 22 in. thick, and are reinforced with eight 1 in. twisted rods, with ¾ in. stirrups. Each caisson of the inner row is anchored by means of a steel rod, 1½ in. in diameter, extending about 10 ft. to a "dead man" buried 7½ ft. underground. This "dead man" is of concrete, 7½ ft. by 3 ft. by 3½ ft. in dimensions.

The junctions of successive panels of the superstructure are made midway between main girders. The reinforcing rods for the beams extend continuously from girder to girder, and, accordingly, for each panel the girder and the beams extending on either side were laid simultaneously as a solid mass of concrete. For each uniform panel 102·4 cu. yards of concrete—cement, sand and rock in the proportion of 1 : 2 : 4—were used. A panel was laid every fourth day, the interval being required for placing the forms and the reinforcing steel. In its complete form, the wharf, which is 656 ft. long, presents from below an imposing appearance of strength and durability, with a graceful Doric effect in the sweep of beams and girders.

For commercial use there will be built a quay wall, or wharf, in two sections, with a total length of 3,235 ft., in addition to 1,860 ft. in the neighbourhood of the dry docks, together with piers at right angles to the axis of the Canal, with their ends about 2,650 ft. from the centre line of the channel. These piers will be 1,000 ft. long and 200 ft. wide, with slips of 300 ft. between, and landings for small boats at the head of each slip for the full width between piers. The main dry dock, designed to accommodate any vessel which can pass through the Canal locks, will have a usable length of 1,000 ft., a depth over the keel blocks of 35 ft. at sea level and an entrance width of 110 ft., the entrance being closed by mitreing gates similar to those used in the locks. The sides of this dry dock, as well as of one near by, having a usable length of 350 ft. and a width at entrance of 71 ft., will be lined with concrete. At the outer end of south-east approach wall to the dry dock will be a coaling plant capable, in the first instance, of handling and storing 100,000 tons.

The large quantity of caisson shell required as supports for the piers and wharves has resulted in the evolution of a special plant for its manufacture. Of this the essential feature is a movable mixer, mounted on a flat car, which is shunted beside the platform on which the collapsible forms and the reinforcement for the sections are set up. Coupled to the "flat" is a box car containing cement, and at the other end are alternate cars of sand and crushed

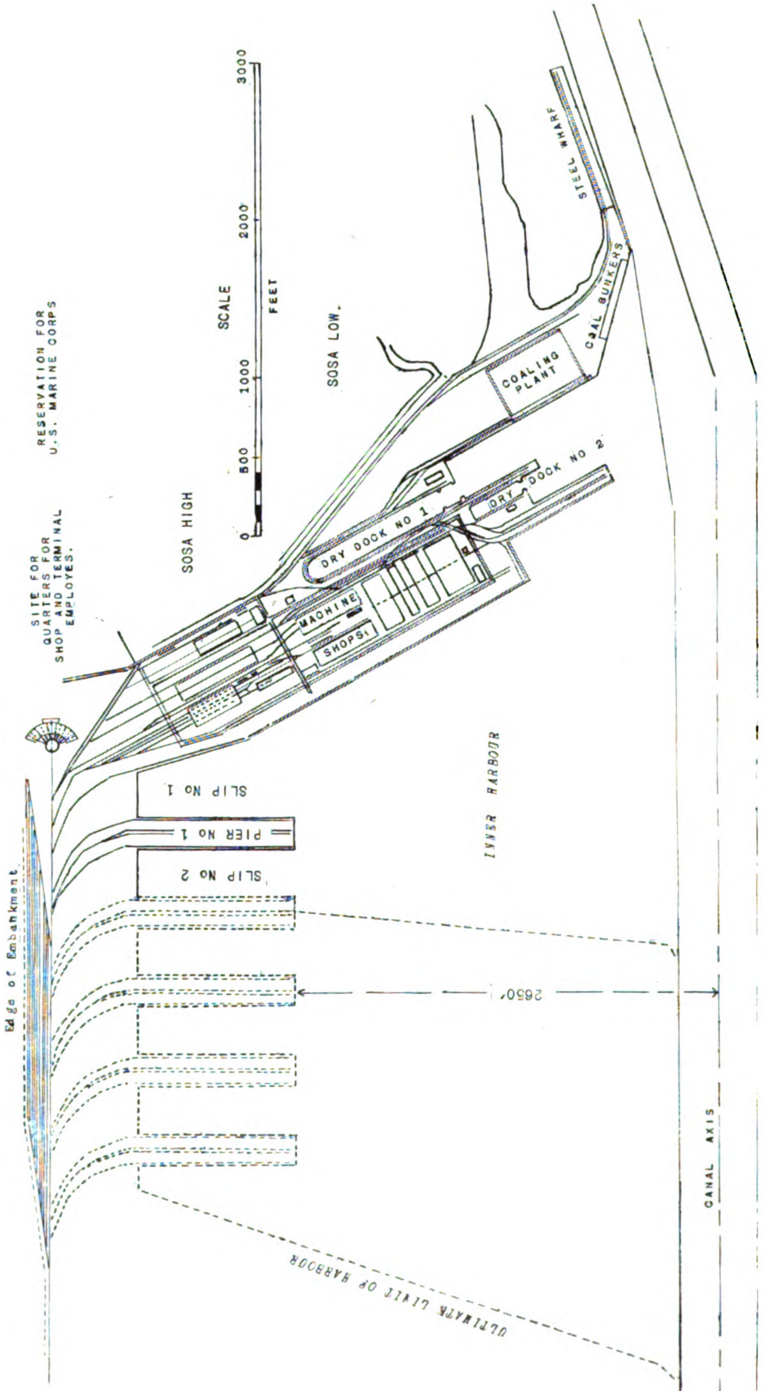


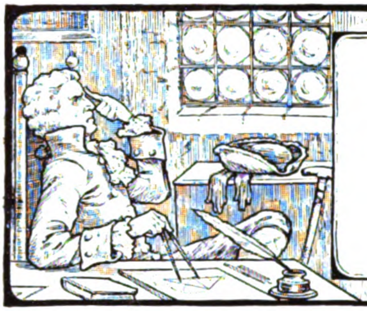
Fig. 8. New Harbour, Machine Shops, &c., at Balboa.
CONCRETE MASONRY IN THE PANAMA CANAL.

rock, all connected in train and moved as a unit. When the train is brought opposite to a form which is ready the concrete is poured into the latter through a chute, the spout being about 14 ft. above the platform. The concrete is allowed to set for twenty-four hours, after which the forms are removed to a special platform to be cleaned and then returned to the operating platform; but the caisson shells remain for three days to harden before removal to a storage yard

At one end of the platform on which the forms are set up and filled is an extension on which the reinforcing steel is assembled. As the bars are unloaded from the cars they are laid in a stock pile at the end of the platform and close to a set of steel rolls. The rods are fed directly into the rolls, which are set to bend them into hoops of a diameter 4 in. less than the outside diameter of the finished shell. The bars are set up around a wooden cage and tied together, after which the reinforcement is handled as one piece. A light derrick mounted on a truck picks up a set of reinforcement, carries it to one of the erected inner forms for the shells, and drops the reinforcement around it. Then six pipes are placed vertically around the reinforcement at equal distances to make cores for connecting rods; the outer form is erected; the space between forms is adjusted with wooden blocks, and the completed form is then ready for the concrete. Each section of shell is 1 ft. thick and 6 ft. high, has an inside diameter of 5 ft. 6 in., and contains 4⅝ cu. yd. of concrete. In all, about 28,000 linear ft. of concrete caisson have been used in pier No. 1 and the adjoining quay wall; and both concrete and steel shells—the latter being used in deep water because of their greater length—are filled with concrete containing a well-protected reinforcement of steel rails.

Extensive, indeed, almost exclusive, use is being made in the construction of the permanent buildings in the new town of Balboa of reinforced concrete and hollow concrete blocks. The latter have been produced on the Isthmus by what is known as the Pauley steam jacket process. During the early part of last year Mr. Albert A. Pauley, the patentee, was appointed by the Canal Commission to superintend the erection of the necessary manufacturing plant, and he remained on the spot until the work of making the blocks was well under weigh and others had been thoroughly instructed in the operation of the machines. Of these fourteen were obtained from the United States—two for making foundation blocks, 12 by 12 by 24 in.; six for main wall blocks, 8 by 8 by 16 in.; two for corner blocks, 8 by 8 by 16 in.; one for partition blocks, 4 by 12 by 12 in.; one for interior columns, 3 by 12 by 12 in.; and two agitators for stirring the concrete before its passage into the block machines. It is stated that each machine is capable of turning out a block every five minutes. The blocks are kept under a constant spray for twenty-four hours, and are then allowed to set for about a week, when, normally, they are ready for use.

(*To be continued*).



SLENDER STRUTS.

By H. KEMPTON DYSON.

The following article has been written by the Author to further explain the question of loads on pillars, which was touched upon by him in his articles which appeared in our journal last year on the London County Council Regulations on Reinforced Concrete.—ED.

A GREAT deal has been written about the strength of slender pillars and struts, and many formulæ have been proposed for calculating the resistance of such members. The majority of these formulæ are in the nature of practical rules of a roughly approximate character. A few have been developed upon what may be termed rational lines, although it is always ambiguous to speak of one formula as being rational and of another as being empirical, because the fact that the latter word signifies something resting upon trial or experiment, or known only by experience, makes it apply in a way to that which is rational or reasoned, for the rule derived by reasoning from observed facts is thus itself the outcome of experience, and can only be employed in connection with factors the values of which are derived from experiment. The common meaning, however, is that an empirical formula rests upon the records of tests on model or full-sized members and/or upon the results of experience in the practical use of full-sized members, while rational formulæ are derived by the application of mathematics to the properties of materials as determined by laboratory experiments. Perhaps a better word than "rational" would be "absolute." The kind of formulæ generally known as Rankine's and Gordon's formulæ for struts are of the empirical character, while Euler's formula is of the absolute or rational type. Of course, Rankine's and Gordon's formulæ have been drawn up upon some sort of reasoning, but they contain constants which are ultimately derived from experiments on model or full-sized struts. Neither absolute nor empirical formulæ can, of course, be asserted as exact, because they ultimately depend upon properties of materials about which the very nature of physical science precludes us from surely dogmatising.

This article is the outcome of the consideration of the extremely onerous rules for determining the loads permitted to be put on pillars by the proposed Regulations for Reinforced Concrete made by the London County Council after preliminary revision by the Local Government Board. It is not the purpose of this article to deal in detail with the mechanics of struts, that subject having been so often threshed out, but rather to apply to reinforced concrete what the writer considers to be the most scientifically practical reasoning in respect to the determination of the resistance of struts which has been put forward. In the writer's opinion the most scientific analysis of the theory of the resistance and the practical design of slender columns is that given by Mr. William Alexander, M.Inst.C.E., in his book entitled "Columns and Struts." Seeing that the subject is there discussed in considerable detail, it will be unnecessary here to go into the matter so fully as he does in that book. The unsatisfactory nature of the older type of rule, derived from an inadequate analysis of the problem, has made engineers nervous in the use of such formulæ, especially in view of the failure of Quebec Bridge in 1907, which, it has been asserted, showed that we possessed inadequate knowledge as to the behaviour of struts that were considerably larger than those upon which experiments had so far been made, thereby confessing that the customary formulæ could only be applied with a feeling of security so far as tested by experiments on full-size members. That, of course, is an innate fault in the empirical formulæ, and, although we should test formulæ of the absolute type by experiment in order to see that there is no fundamental error in their derivation, we feel much more confident in their use because they are certain to apply to cases outside the limits of known experiments, even if they have to be modified slightly. The absolute formulæ have been verified by such experimental work, and Mr. William Alexander, by making several simplifying approximations which make no appreciable difference to the values obtained, has succeeded in arriving at a very practical type of formula of general application.

The true curve into which a strut is bent by the application of a load applied directly at its ends is called the elastica or lintearia. A strut will not start to bend until a load of a certain amount is applied. The absolute formula which gives the limits of loads that will start bending may be derived in various ways, but it was derived in one way by Euler and is known as Euler's formula. As a strut bends more and more its resistance to bending increases, and the load that will start bending is therefore not so great as the crippling loads. Euler's formula makes it appear that the strength of a strut varies inversely as the square of the length, but this is not absolutely true, though, within certain limits, is nearly so. Tredgold originally developed the type of formula known in two forms as Gordon's and Rankine's. He assumed a length of rectangular strut of uniform cross section long enough for bending to be likely to occur.

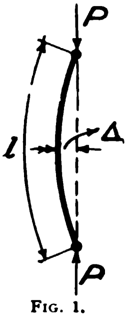


FIG. 1.

Referring to *Fig.* 1, let

P = the total pressure or load on the strut.
l = the length.
A = the cross-sectional area.
Δ = the deflection at the centre produced by the load.
p_d = the intensity of direct pressure $= \frac{P}{A}$.
p_b = the intensity of pressure due to bending.
d = the least diameter of the strut.
b = the breadth of the strut at right ang es to d.
u = intensity of ultimate fibre stress.
C = a constant.

If we regard the cross section at the middle due to the bending moment caused by the eccentricity of the line of application of the load, we have:—

$$p_b \text{ varies as } \frac{P\Delta}{bd^2},$$

it being assumed that the bending will take place in the direction of d.

Then assuming that the deflection varies directly as the square of the length and inversely as the diameter, we have—

$$\Delta \text{ varies as } \frac{l^2}{d},$$

while $$bd^2 \text{ varies as } Ad.$$

Therefore $$p_b \text{ varies as } \frac{P}{A} \cdot \frac{l^2}{d^2}, \text{ or as } p_d \frac{l^2}{d^2}.$$

But $u = p_d + p_b$. Therefore $$u = \frac{P}{A}\left(1 + C\frac{l^2}{d^2}\right) \qquad (1)$$

A strut with pin-connected ends being twice as flexible as one having its ends fixed in direction, the constant for pin-ends needs to be four times as great as for fixed ends, Therefore, as the fixed-end type is the stiffest possible, its constant will be the least, and if we call this C_1, the corresponding value for the pin-ended type is $4C_1$.

Transposing the foregoing equation, and including the constant for pin-ends, we have—

$$P = \frac{uA}{1 + 4C_1\frac{l^2}{d^2}} \qquad (2)$$

Hodgkinson carried out numerous experiments on cast-iron and wrought-iron pillars, from which Gordon suggested values of the constant C_1, and the formula

$$P = \frac{uA}{1 + C_1 \frac{l^2}{d^2}} \tag{3}$$

is generally known as Gordon's formula. The value of the constant as given by Gordon varies very much with the form of the pillar, namely, as to whether it is rectangular or circular, hollow or solid. Rankine therefore substituted for the factor d^2 the value $12g^2$ (in which g = the radius of gyration of the section in the direction of bending) because, the sections on which experiments were made being rectangular, $d^2 = 12g^2$.

Rankine's formula is therefore—

$$P = \frac{uA}{1 + C_2 \frac{l^2}{g^2}} \tag{4}$$

and is often called the Rankine-Gordon formula.

The assumptions in it of the strength varying inversely as the square of the length, u varying directly as P, and that bending will take place in the direction in which g is least, are all untrue. The one constant employed in the foregoing formula has to provide for all possible causes of departure from ideal conditions that are met with in practice and for all the effects of variation in the form of cross-sections, while as employed it is distinctly empirical in that the constant is chosen so as to make it agree with the average results of as large a number of experiments as possible, without discrimination.

Various modifications have been proposed in this formula to cover observed deviations from the predicted results, but fundamentally they are all inexact, being based on assumptions which are not absolutely true.

Absolute formulæ for bent struts entail the use of elliptic integrals and are not very convenient of application. There is no need to give the formulæ here—they are set out in detail by Mr. Alexander, who shows that Euler's formula is only a singular value obtainable from the general equations by setting the limit that the deflection shall be *nil*.

Euler's formula is

$$P = \frac{EI\pi^2}{4l_c^2} = \frac{\pi^2 EA}{4} \cdot \left(\frac{g}{l_c}\right)^2 \tag{5}$$

or

$$p_d = \frac{P}{A} = \frac{\pi^2 E}{4} \cdot \left(\frac{g}{l_c}\right)^2 \tag{6}$$

the meaning of the symbols being given later.

Mr. Alexander goes on to show how if values are assigned to the intensity of ultimate fibre stress (such as limiting it to the value of the elastic limit or yield point) and to the direct compressive stress the absolute equations become determinant as to the ratio l_c/g, giving results which show in an extreme case ·23 per cent. increase on the value of l_c/g obtained from Euler's formula—a quite negligible amount as regards the calculation of the safe resistance, though making all the difference as regards the determination of the deflection and curvature. For ideal conditions of loading, therefore, we may substitute Euler's formula for all practical purposes, but we must remember that if we set a limit to the value of p_d we limit the value of g/l_c, which shows that below the value thus obtained no bending will result and we could load the section to the full limiting direct stress. In practice, however, we never obtain ideal conditions, the departure therefrom being in respect to inequalities in the manufacture causing a want of homogeneity in the material resulting in a variation in the value of the modulus of elasticity from point to point of a section, and the want of alignment in the longitudinal axis resulting in the load at the end of the strut being applied out of its longitudinal axis. These main causes and some minor ones result in a strut deforming more on one side than on another, and may all be taken together as accidental eccentricity in the application of the load.

Mr. Alexander shows how by an approximation that involves a practically negligible error we can express the effects of such eccentric application of the load by the following modification of Euler's formula :—

$$l_c=\sqrt{\frac{EI}{P}}\left\{\frac{\pi}{2}-\frac{e}{g}\cdot\frac{n}{g}\cdot\frac{p_d}{p_b}\right\} \qquad (7)$$

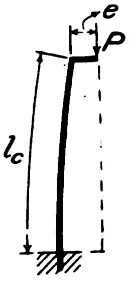


FIG. 2.

where A = area of strut.
E = modulus of elasticity.
e = eccentricity of line of thrust (see *Fig.* 2).
g = gyration radius.
I = moment of inertia $=Ag^2$.
l_c = length from centre point of a curve to a point of contrary flexure (see *Figs.* 2 and 3).
n = distance of extreme fibre of cross-section from the neutral axis.
P = total load.
p_d = direct pressure intensity $=\frac{P}{A}$
p_b = pressure intensity due to bending.
u = permissible ultimate strength of short concrete specimen $=p_d+p_b$.
Q = qualifier of reduction on direct compressive stress. Therefore QuA = maximum load sustainable.

Both this and Euler's formula will now be put in a form specially suitable for plotting on a diagram.

Thus, substituting $p_b=u-p_d$, $p_d=Qu$ and $I=Ag^2$, in (7) we have

$$l_c=\sqrt{\frac{EAg^2}{P}}\left\{\frac{\pi}{2}-\frac{e}{g}\cdot\frac{n}{g}\cdot\frac{p_d}{u-p_d}\cdot\right\}$$

$$=g\sqrt{\frac{E}{p_d}}\left\{\frac{\pi}{2}-\frac{e}{g}\cdot\frac{n}{g}\cdot\frac{p_d}{u-p_d}\right\}$$

$$l_c/g=\sqrt{\frac{E}{Qu}}\left\{\frac{\pi}{2}-\frac{e}{g}\cdot\frac{n}{g}\cdot\frac{Qu}{u-Qu}\right\}$$

$$=\sqrt{\frac{E}{u}}\left\{\frac{\pi}{2\sqrt{Q}}-\frac{e}{g}\cdot\frac{n}{g}\cdot\frac{\sqrt{Q}}{(1-Q)}\right\} \qquad (8)$$

Also substituting in (6)

$$l_c/g=\frac{\pi}{2}\sqrt{\frac{E}{p_d}}=\sqrt{\frac{E}{Qu}}\cdot\frac{\pi}{2}=\sqrt{\frac{E}{u}}\cdot\frac{\pi}{2\sqrt{Q}} \qquad (9)$$

A formula of the Rankine-Gordon type may also be derived in another way, which gives a form more suitable for plotting in conjunction with the foregoing. Thus :—

If a column is very stiff, then it is true that

$$P_s=uA \qquad (10)$$

while, if it be very slender, Euler's formula will be true, and

$$P_e=\pi^2\frac{EI}{4l_c^2} \qquad (11)$$

Then the equation

$$\frac{1}{P}=\frac{1}{P_s}+\frac{1}{P_e} \qquad (12)$$

fits the condition that when the strut is very short strut $P=P_s$ nearly (for in this case $\frac{1}{P_e}$ becomes negligible), and for a long strut $P=P_e$ nearly (for in this case $\frac{1}{P_s}$ becomes negligible). Therefore, by substituting (10) and (11) in (12) we can write—

$$P=\frac{1}{\frac{1}{P_s}+\frac{1}{P_e}}=\frac{1}{\frac{1}{uA}+\frac{4l_c^2}{\pi^2EI}}=\frac{uA}{1+\frac{4ul_c^2A}{\pi^2EI}} \qquad (13)$$

and
$$P = \frac{P_s}{1 + \frac{4ul_c^2 A}{\pi^2 EI}} \tag{14}$$

From (13) we obtain Rankine's formula—

$$P = \frac{uA}{1 + C_2 \frac{l_c^2}{g^2}} \quad \text{where} \quad C_2 = \frac{4u}{\pi^2 E} \tag{15}$$

and also Gordon's formula—

$$P = \frac{uA}{1 + C_1 \frac{l_c^2}{d^2}} \quad \text{where} \quad C_1 = \frac{4u}{\pi^2 EN},$$ N being the numerical coefficient in the equation $I = NAd^2$.

From (14) we see that the value of Q by Rankine's formula is—

$$Q = \frac{1}{1 + \frac{4u}{\pi^2 E} \cdot \left(\frac{l_c}{g}\right)^2} = \frac{1}{1 + \left(\frac{2l_c}{\pi g}\sqrt{\frac{u}{E}}\right)^2}$$

Calculations of the resistance of struts by the foregoing formulæ are most easily performed by the aid of diagrams and Euler's, Rankine's and the modified Alexander's formulæ have been plotted by the writer on *Fig.* 3

In using this diagram, except for the Euler and Rankine lines, we need to determine the value of a constant marked $\frac{n}{g} \cdot \frac{e}{g}$

The determination of this constant depends upon our choice of e because the value of n and the value of g are strictly determinate, depending only upon the form of the section. In giving values for e (which is the eccentricity of the line of thrust in the strut) we have to bear in mind the practical conditions under which struts are employed in practice. The causes of departure from ideal conditions of true axial thrust have already been referred to. Of course an eccentricity obtained by design is known, but we require to gain some idea of the accidental eccentricity. Firstly, we may consider the eccentricity that may be due to want of homogeneity in the material, which results in a variation in the value of the modulus of elasticity from point to point of the section, and causes a want of coincidence between the geometric axis and the neutral axis. This is very clearly shown in the case of the ordinary theory of the position of the neutral axis in a reinforced concrete beam where two materials of very different moduli of elasticity are being used. In a steel strut we know that the material will show a very appreciable difference in the modulus of specimens cut from different parts, which means that if the section be loaded it will give way more in one direction than in another, and the neutral axis will therefore be displaced from the geometric position. In a reinforced concrete pillar, as a rule, the steel sections are symmetrically placed, but whether due to incorrect placing, or whether from the somewhat greater risk of want of homogeneity in the concrete, the neutral axis of the combined section, in which the steel has a different elastic modulus to the concrete, will surely not coincide with the geometric axis. Internal stresses are, of course, another minor cause of irregularity. Such internal stresses may result by contraction of the concrete or by the rolling of the steel and even by changes of temperature. The variation in the modulus of elasticity will in all probability take place over a smaller range as the sectional area increases, because with the larger section the average value would be more uniform. Then again, the longer the column the greater probability of uniformity, because as the length increases the number of cross-sections increases, and with it the probability that variations in the modulus will not take place in the same direction in all of the sections, so that one will neutralise the other and the resulting effect on the whole will decrease. Therefore we may say that any eccentricity in the load due to variation in the modulus of elasticity will show a decrease with an increase of the lateral dimensions (which is the same thing as saying the radius of gyration) and with increase in the length of the strut. The net result is therefore probably that variation in the ratio

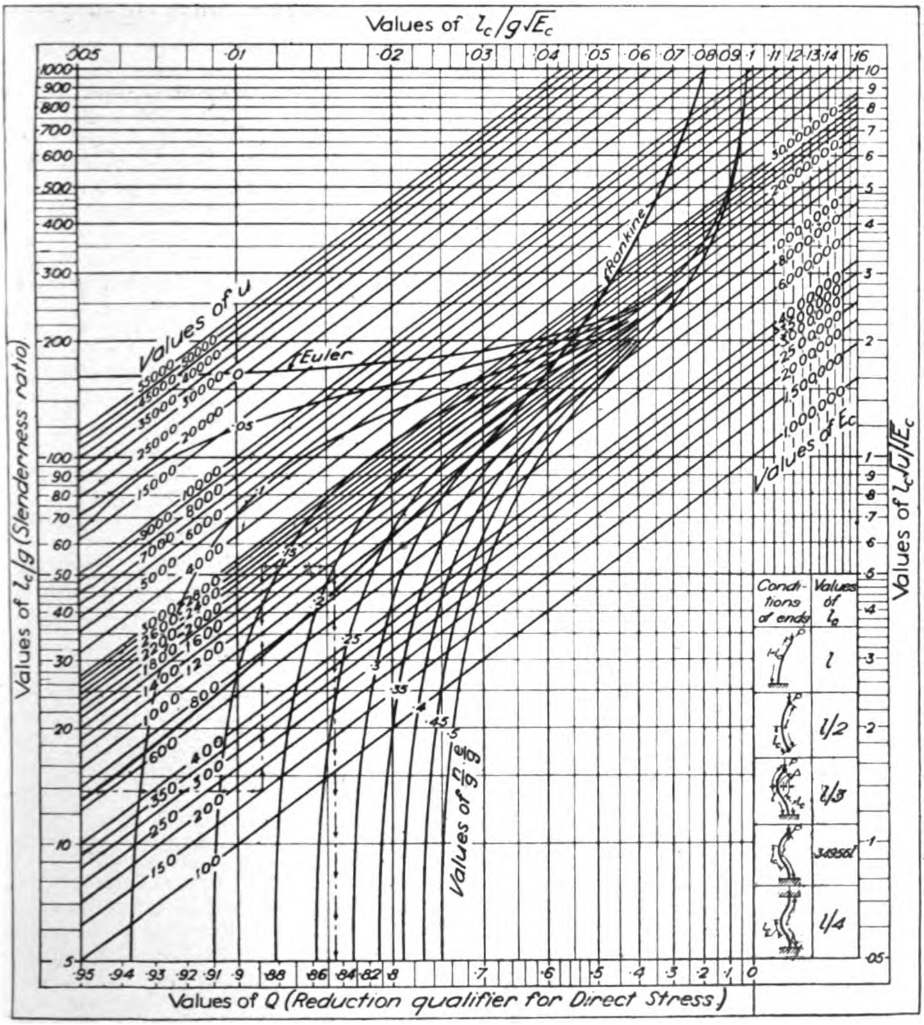


FIG. 3. [*Copyright reserved by author.*]

of l_c/g will not appreciably effect any variation in the accidental eccentricity. The second and most fruitful cause of eccentricity is inaccuracy in workmanship, whereby the strut is not properly centred or put in true alignment. We should expect that any difficulty in manufacturing the strut and putting it into place so as to secure axial loading will certainly not be decreased with an increase of its length. Therefore it should be assumed that the longer the strut the greater the accidental eccentricity due to inequality of workmanship. Finally, we have eccentricity due to the application by design of a load out of the centre. This, however, is of known value, and may be ignored when we are endeavouring, as at present, to arrive at some reasonable values for the two causes of accidental eccentricity before referred to.

In building work it is seldom that columns are fixed at one end and are free, or merely hinged at the other, although, perhaps, in the majority of cases the columns are not properly fixed at the ends. As to what value should be given to the accidental eccentricity due to variation in the modulus and internal stresses, we can only go by experimental data, from an inspection of which it would appear that we should set the limit under the very best conditions—*i.e.*, in the case of struts which are adequately fixed at the ends—that the value $\frac{e}{g}$ should never be less than 0·1.

We now have to derive a reasonable value to take for the eccentricity that may be due to a strut not being set in its true alignment. The mere placing of a strut out of centre, apart from the question of it being inclined to the line of thrust, is not likely to vary much in amount with variation in size, and consequently becomes less serious as the lateral dimensions increase. Such variation is already sufficiently provided for by the foregoing allowances. The difficulty of setting a pillar upright is, however, an important matter. If we assume that in practice a short pillar 5 ft. long may be put ½ in. out of the upright, and that this might be increased to 1 in. in the case of a strut 10 ft. long, we could express this as a rule by taking the eccentricity in inches as $0{\cdot}01l$. The possible eccentricity due to variation in the modulus becomes negligible in such cases compared with this eccentricity due to imperfect workmanship, and may be ignored, so that the writer arrives at the conclusion that the accidental value of $\frac{e}{g}$ should in no case be taken as less than 0·1, and otherwise that the value should be derived by assuming e to be either $0{\cdot}01l$ or one half-inch, whichever is the greater. The accidental eccentricity due to inclined setting of the pillar derived in this way will be fully effective in the case of a pilar fixed only at one end and perfectly free at the other, as shown in *Fig.* 2, but will be reduced in the same proportion as the total length l is reduced to l_c by being forced to bend in various ways for various manners of end holding.

In order to apply Alexander's formula we need to ascribe values to the other constants, namely, l_c, E and u. As regards the latter, namely E and u, it must be recollected that the formula applies solely to the limiting condition of the practical ultimate strength. Indeed that also is the case with both Rankine's and Euler's formulæ. In the case of steel the modulus is only fairly constant up to the yield point of the steel, but as the values we have taken above for determining the accidental eccentricity provide for variations in the modulus, the limiting values become $E = 30{,}000{,}000$ lbs. per sq. in., and $u = 50{,}000$ to 55,000 lbs. per sq. in. in the case of steel, the latter being the yield point, and the ultimate compressive resistance for ordinary mild steel. In the case of cast-iron, timber, stone, and plain concrete there is no uniform value of the modulus, this becoming less as the stress increases. We may, however, take the average modulus over the whole period of loading; thus we derive the value of E by taking the ultimate stress and dividing it by the ultimate strain. In the case of a compound section of two materials like reinforced concrete, we are faced with the difficulty that the concrete has a variable modulus while the steel has a comparatively uniform one, and therefore the relation of the one modulus to the other is constantly changing, which means that the equivalent section, namely, that in which the area of the steel is multiplied m-fold, m being the ratio of the moduli of elasticity, E_s/E_c, is likewise continuously changing. The difficulty is, however, solved for us by the simple consideration of what happens to a reinforced concrete pillar when it is loaded to destruction. We find that as the stress increases the concrete is strained faster than the steel, and consequently the stress on the steel is continually increasing at a faster rate than the stress on the concrete until at the ultimate load the concrete is carrying all that it is able to sustain and the steel is forced in turn to carry the remainder of the load up to its maximum resistance. The two materials therefore break down together. Assuming, therefore, that the steel has a uniform modulus, up to that point, of 30,000,000 lbs. per sq. in., and that stress ÷ strain = modulus, as the strain is the same for both materials we have the relation :—

$$\text{Strain} = E_c/u_c = E_s/u_s$$

from which

$$E_c = E_s \,.\, \frac{u_c}{u_s}$$

Supposing, therefore, we have a concrete whose ultimate compressive resistance is 2,400 lbs. per sq. in., when the ultimate compressive strength of the steel is 50,000 lbs. per sq. in., we find from the above that the modulus of the concrete

$$E_c = 30{,}000{,}000 \times \frac{2{,}400}{50{,}000} = 1{,}440{,}000 \text{ lbs./in.}^2$$

or
$$E_c = \frac{30{,}000{,}000}{50{,}000} \cdot u_c = 600u_c$$

The modular ratio will, of course, be $m = \frac{E_s}{E_c} = \frac{u_s}{u} = \frac{50{,}000}{u_c}$

To justify the adoption of 50,000 lbs./in² as the ultimate stress in the steel, the spacing of the links should be close enough to enable this stress to be developed in the rods regarded as slender struts in themselves, *i.e.*, the pitch of the laterals should not be greater than 16 times the diameter of the least vertical bar.

In choosing average values for the ultimate compressive resistance of concrete, it should be remembered that the limits customarily set to the minimum strength required by specifications, reports and regulations to be shown by tests on moulded cubes do not represent average values nor the actual strength of concrete as put into the work in practice. The author has already dealt with this in an article on pp. 604 and 605 of the issue of CONCRETE AND CONSTRUCTIONAL ENGINEERING, Vol. VIII., No. 9, September, 1913. The average strength in practice will possibly be 20 per cent. higher than the values obtained from test cubes, while in the event of the maximum stress being realised only on the extreme fibre the approximately parabolic stress distribution due to variation in the modulus of elasticity of concrete as the stress increases will serve as an additional reason for taking a higher value than the limit set for test cubes.

It only remains to find the value of l_c. This, of course, will vary for different conditions of ends and for different values of the eccentricity and different ways in which it is applied. An exact solution is difficult to derive, and the usual conditions are generally not departed from sufficiently to make it worth while determining its exact value. Indeed, to do so would mean employing the long, unmodified absolute formulæ, and considering the other factors are not known with any great degree of accuracy it would be in great part a waste of time. The value of l_c is therefore best derived for a few standard cases and under ideal conditions, namely, by Euler's method.

In the case of a strut fixed at one end and free to move at the top (as in *Fig.* 2) the value of l_c is obviously equal to l.

In the case of a strut hinged at both ends and maintained in the same lateral position, the value of l_c is $l/2$, the form of flexure being shown on *Fig.* 3.

If both ends of a strut are rigidly fixed and held against turning, the elastic curve will have two points of inflexion, and from symmetry the tangent to the elastic curve at the centre must be parallel to the original position of the axis of the strut. Therefore the portions of the curve must all be symmetrical, and consequently the points of inflexion occur at one-fourth the length of the strut from either end, and we get $l_c = l/4$.

This may, however, be derived mathematically as follows (see *Fig.* 4): Let both ends be fixed against turning by a moment M at each support. Then the moment at a point distant x from O is $M_x = M - Py$, and the equation of the elastic curve is

$$EI.\ \frac{d^2y}{dx^2} = M - Py.$$

Integrating we have

$$y = A \sin\left(x\sqrt{\frac{P}{EI}}\right) + B \cos\left(x\sqrt{\frac{P}{EI}}\right) + \frac{M}{P}$$

in which A and B are constants, which can be determined by the conditions that $y=0$ when $x=0$. We find thereby $A=0$ and $B = -\frac{M}{P}$. Also $y=0$ when $x=l$. Therefore we have $B \cos\left(l\sqrt{\frac{P}{EI}}\right) + \frac{M}{P} = 0$. Likewise $\frac{dy}{dx} = 0$ when $x = l$; therefore $-B\sqrt{\frac{P}{EI}} \sin\left(l\sqrt{\frac{P}{EI}}\right) = 0$.

From these conditions,

$$\cos\left(l\sqrt{\frac{P}{EI}}\right) = 1$$

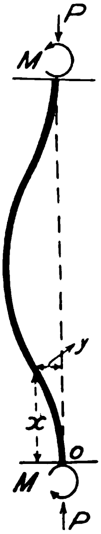


FIG. 4.

and

$$\sin\left(l\sqrt{\frac{P}{EI}}\right)=0$$

whence

$$\left(l\sqrt{\frac{P}{EI}}\right)=2\pi$$

from which

$$P=\frac{4\pi^2EI}{l^2}$$

Also

$$\frac{d^2y}{dx^2}=\frac{M}{EI}-\frac{P}{EI}y$$

and

$$y=-\frac{M}{P}\cos\left(x\sqrt{\frac{P}{EI}}\right)+\frac{M}{P}$$

Equating $\frac{d^2y}{dx^2}$ to zero, we have

$$\cos x\sqrt{\frac{P}{EI}}=0$$

and

$$x\sqrt{\frac{P}{EI}}=\frac{\pi}{2}\text{ or }\frac{3\pi}{2}$$

But as $l\sqrt{\frac{P}{EI}}=2\pi$, then $\sqrt{\frac{P}{EI}}=\frac{2\pi}{l}$

whence $x=\frac{l}{4}$ or $\frac{3}{4}l$.

Therefore the points of inflexion are situated $l/4$ away from the ends.

In the case of a strut fixed at one end and hinged at the other, but not maintained by the hinge in its original lateral position, being guided instead into a position where the lateral movement of the free end is half the total deflection, the elastic curve has points of inflexion at one-third and two-thirds of the length, as shown in *Fig.* 3, and $l_c=l/3$.

(To be continued.)

GRAND STAND, HURST PARK RACECOURSE.

Reinforced concrete is fast replacing timber for structures such as the one described in the present article, and we have already given various examples of grand stands erected not only in this country but in the United States. As indicated in the article, reinforced concrete is particularly suitable for buildings of this description, as there are practically no maintenance charges. Our article has been prepared by Mr. Albert Lakeman, Hon. Medallist Construction.—ED.

OWING to the timber stand having been destroyed by fire, it became necessary to reconstruct the grand stand at Hurst Park Racecourse, and advantage was taken of this necessity to increase the accommodation, and at the same time to employ reinforced concrete as the material for the constructional members, to prevent a recurrence of a disaster of this kind.

The new stand, as now completed, is one of the most up-to-date and commodious in the country, and it requires no maintenance, which is a very important consideration. The total length of the stand is 164 ft., and the width 52 ft., while it has a height of 36 ft. from the ground-floor level to the eaves. There are practically three floors, apart from the ordinary accommodation, which is capable of taking 7,500 spectators, and these floors are utilised for luncheon- and drawing-rooms and cloak-rooms. The luncheon-room on the ground floor for members is 62 ft. 6 in. by 39 ft., and in addition to this there are two grill-rooms, each 37 ft. 6 in. by 39 ft., one of which is for the use of members and the other for reserved enclosure ticket holders. The kitchens are provided on the first floor, and these are extensive and fitted up in an approved modern style, with every facility for efficient and quick service and cooking. The remainder of this floor is devoted to cloak-rooms for ladies and gentlemen. The second floor is designed to provide a suite of drawing-rooms, which are tastefully furnished and enclosed on both sides with glazed framing, which enables the users to watch the races in complete comfort, even in the most inclement weather. A splendid view of the entire course can be obtained from these rooms through the front windows, and at the back a view is obtained of the paddock, the casements being arranged to slide, thus enabling the rooms to be opened up during fine weather. Every effort has been made throughout to provide the maximum amount of comfort for members and others using the stand, and a central heating apparatus is installed for heating the building throughout.

The general heights and arrangement of the different floors can be seen in *Fig.* 1, which is a cross-section of the stand. It will be noticed that the existing retaining wall at the front is utilised, and that the kitchens come behind the tiers for the spectators, and thus no space is wasted. The whole of the reinforced concrete work was designed and executed on the Mouchel-Hennebique system, from details and drawings prepared by Messrs. L. G. Mouchel and Partners, Ltd., of Westminster.

The general effect of the back of the stand, which is shown in the photograph in *Fig.* 4, is interesting, as it will be noticed that the horizontal and vertical lines are obtained by the reinforced beams and columns, while the panels are filled in with Mouchel patent monolithic hollow-block walling, reinforced throughout and finished on the exterior with rough cast. A cross-section showing the constructional members is given in *Fig.* 3, and it will be seen that there are three longitudinal rows of columns spaced at 12 ft. 6 in. centres. The spacing was also equal to this amount in the longitudinal direction, thus dividing the bays up into perfect squares.

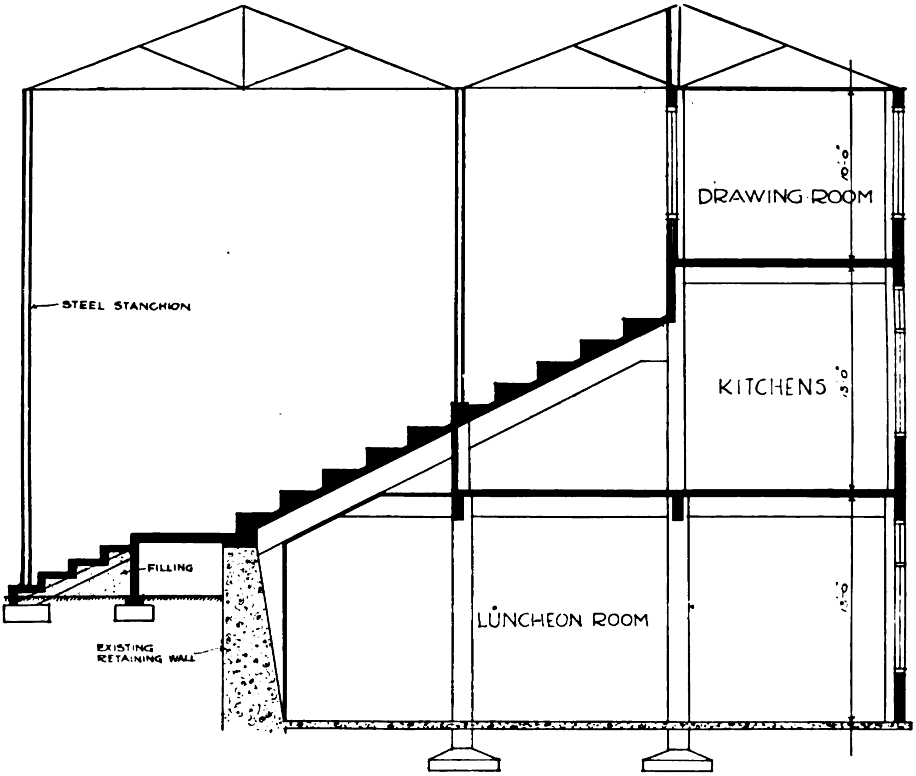


Fig. 1 Cross Section of Stand.
REINFORCED CONCRETE GRAND STAND, HURST PARK RACECOURSE

These columns are all 14 in. square, and they are reinforced with four lines of vertical reinforcement, with links at 4 in. centres, and they have a reinforced concrete foundation slab 4 ft. square and 5 in. thick at the extreme outer edge, increased to 1 ft. 4 in. at the point of intersection with the column shaft. The slabs are reinforced with a lattice, consisting of rods in both directions in the underside, with connecting stirrups running up to a similar lattice

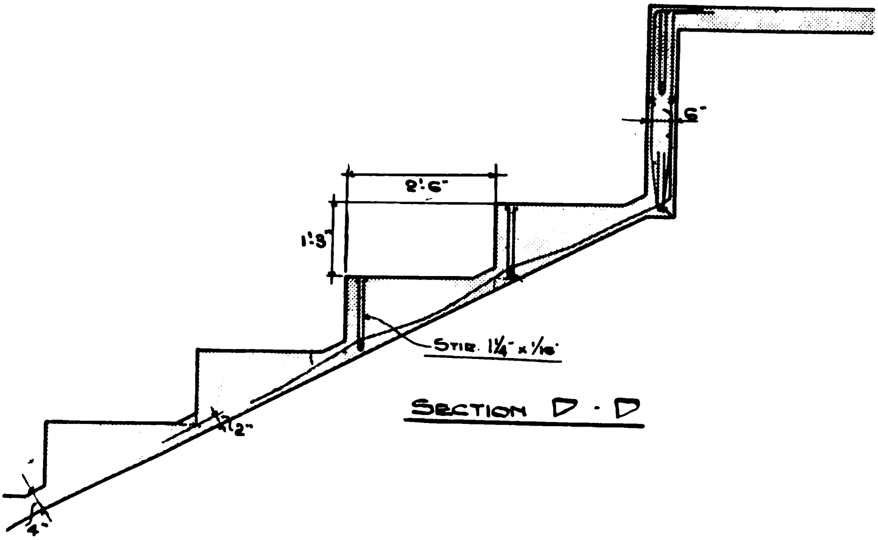


Fig. 2. View Showing Section of Stand.

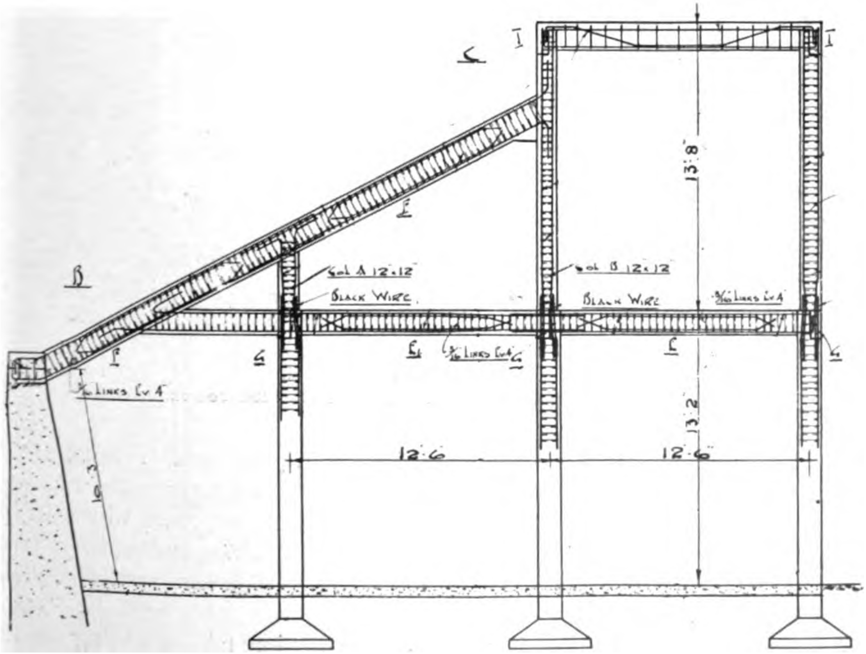


Fig. 3. Cross Section.

Reinforced Concrete Grand Stand, Hurst Park Racecourse.

at the level of about the centre of the depth. The main column rods are turned out at right angles at the bottom to assist in the distribution of the weight. The slabs forming the floors are designed on the continuous principle, and these are 4½ in. thick, with small bars in both directions and surfaces, and the main beams, as shown in *Fig.* 5, are 16 in. or 14 in. deep and 7 in. or 8 in. wide, and reinforced with either four or eight rods, according to the load, half of the number being placed in the upper and half in the lower surface. The two sets of reinforcement are connected by links, and where no rods are required in the compression area some of the bars are cranked up at the ends, and stirrups are provided at variable distances.

The stepped portion which slopes back at the angle shown in the section is formed with treads 2 ft. 6 in. wide, and risers 1 ft. 3 in. high. A detail of this work is shown in *Fig.* 2, and it will be seen that two longitudinal rods are placed in the soffit close to the intersection of tread and riser, with stirrups carried well up into the mass of the concrete. In addition to this, transverse bars are provided in the soffit which are cranked to pass over the longitudinal rods in each case.

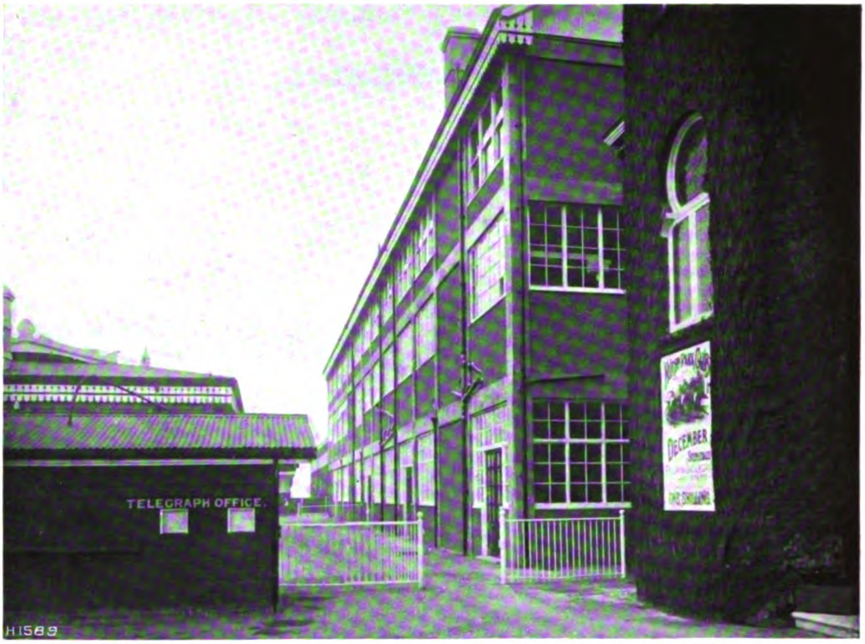


Fig. 4. View Showing Back of Stand.
REINFORCED CONCRETE GRAND STAND, HURST PARK RACECOURSE.

The raking beams supporting the sloping portion take a bearing on the retaining wall at the foot of the slope, the old concrete at the top of the wall being broken off and rebuilt with the beams to form a monolithic construction. The whole of the structure is covered by a roof composed of steel trusses and

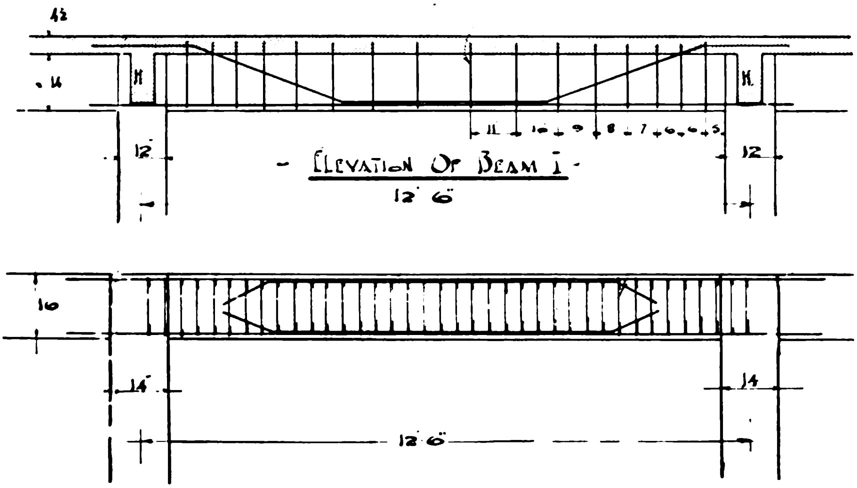


Fig. 5. Reinforced Concrete Main Beams.

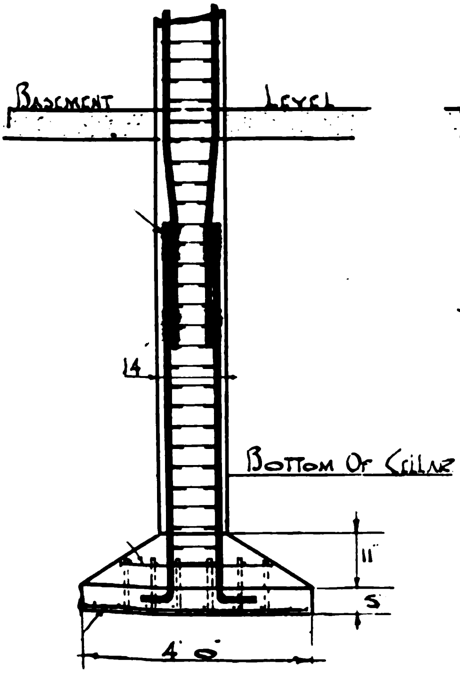
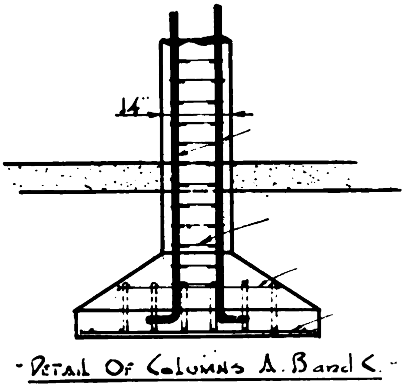
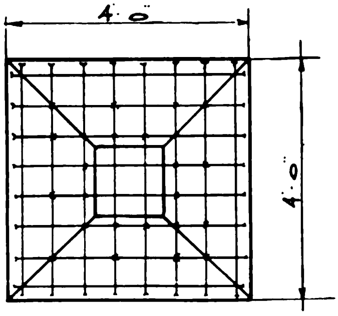


Fig. 6. Detail of Column.





Detail of Slab.

Reinforced Concrete Grand Stand, Hurst Park Racecourse.

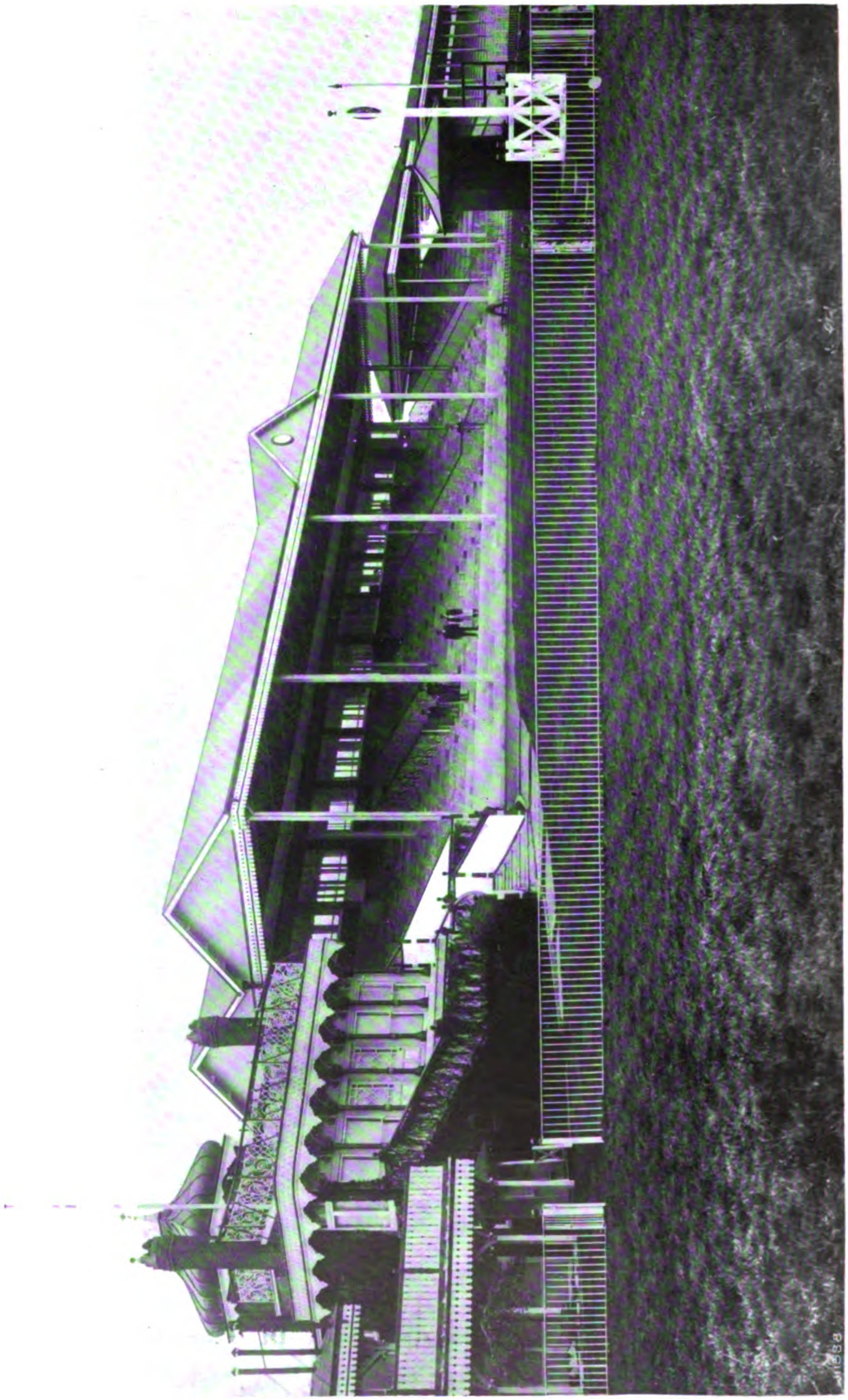


Fig. 7. View of Finished Structure.

Reinforced Concrete Grand Stand, Hurst Park Racecourse.

purlins, covered with wrought boarding, upon which is laid a non-flammable, durable roofing material.

The whole scheme is well planned and constructed in such a manner that it is fire-resisting and durable, and will require practically no maintenance, while its appearance is simple and pleasing. The contractors for the general construction and reinforced concrete work were Messrs. Stephen Kavanagh and Co., of Surbiton.

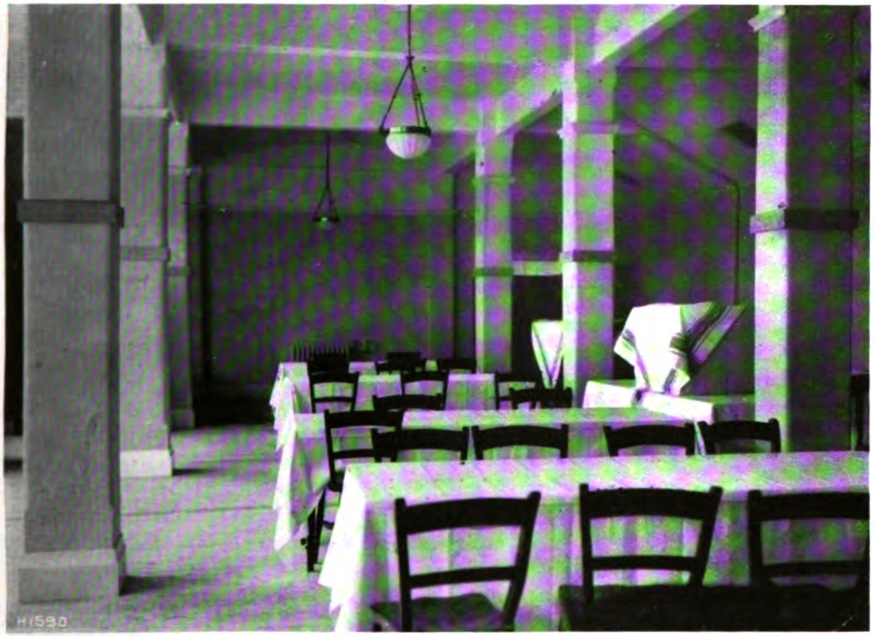


Fig. 8. A Corner of the Grill Room.
REINFORCED CONCRETE GRAND STAND, HURST PARK RACECOURSE

STANDARD METHOD OF MEASUREMENT FOR REINFORCED CONCRETE.

The following is the Draft Report of the Joint Committee of Representatives from the Quantity Surveyors' Association, the Quantity Surveyor Members of the Concrete Institute, and the Reinforced Concrete Practice Standing Committee of the Concrete Institute, presented at their 43rd Ordinary General Meeting. A Discussion followed, of which we give a short summary.—ED.

THE following Draft Report was presented after the Committee had held several meetings, and the Report is accompanied by the following recommendation :—

> "That the method of measurement as compiled by your representatives and as copy enclosed be adopted, signed by the signatory bodies, printed, registered at Stationers' Hall, and circulated among the Members of the Concrete Institute and of the Quantity Surveyors' Association."

The Committee further recommended that in cases in which the working details are not complete engineers indicate for the guidance of their surveyors when preparing the quantities the thicknesses and weights of reinforcement as shown upon the drawings herewith.

In submitting the report, Mr. S. BYLANDER (Vice-Chairman of the Reinforced Concrete Practice Standing Committee of the Concrete Institute) stated that in order to further the interest of reinforced concrete, simplification was necessary. The chief thing to be aimed at was to obtain a result, and the means to this end should be as simple as possible. If any part of the work entailed too much expense, it was their duty to reduce that amount of work so that only useful work would be necessary. Undoubtedly, when using a new material, it afforded a better opportunity to standardise. He thought the Institute had done well in asking the Quantity Surveyors' Association to join hands with them in trying to draw up something which would be of mutual advantage to professional engineers as well as to quantity surveyors.

The Quantity Surveyors' Association and the Concrete Institute would ultimately decide on the final form, after having heard the criticisms of that meeting.

With reference to concrete generally, the Committee had, in carrying out the general idea of simplification, decided to adopt the foot as a unit, and not the yard, in order to avoid mistakes and unnecessary transference from one unit to another. It was certainly to the interest of every professional institution to work together in advancing the knowledge of the subject, and to reduce the amount of unnecessary clerical work in order that they might concentrate their minds upon things that mattered, and by using one unit they could attain that object.

As to the tabulated form which accompanies the second report, this was not intended as a bill of quantities to present to the builder, but only as a sheet in which the details of the quantities were given from the drawings, so that they could at once trace the quantities allowed for on the design. He then gave a detailed explanation of the various headings comprised in the sheet.

REINFORCED CONCRETE.

Suggested Method of Measurement.

The work on each floor to be kept separate, stating the height from the ground to the several floors. Keep concrete, centering and reinforcement for each floor together. No reinforcement to be deducted from the concrete; otherwise all measurements to be net unless stated, and notwithstanding any trade custom, to the contrary.

CONCRETE.

Foundations, per ft. cu.

Bases to pillars, per ft. cu.

Walls (State each thickness separately), per ft. cu.

Pillars (State "averaging........." or "ranging from.........to........."), per ft. cu.

Floor Slabs (Measure across beams; state each thickness separately), per ft. cu.

Beams (Measure below soffit of floor slab; state "averaging........." or "ranging from.........to........."), per ft. cu.

Roofs (State slopes over 30 degrees separately to allow for filling between double centering), per ft. cu.

Chases and Grooves, Etc. (Whether cut or formed to be described), per ft. run.

Holes, Mortices, Etc. (To be described as either cut or formed, and size, depth, or thickness of concrete given), each.

CENTERING, SHUTTERING, etc.

Each variety of centering, shuttering, etc., to be measured separately. Both sides of concrete requiring double centering to be measured.

Foundations—Vertical, splayed or circular, per sq.

Walls—Vertical, battering or circular on plan, per sq.

Floor Slabs—Raking, circular on plan, or radiating (measure net between beams; the radiating centering to be described as including all cutting to radiations), per sq.

Ditto, in Small Pieces, Landings, Etc., per ft. super.

Pillars—All centering, etc., to include for strutting, timbering, wedges, etc.; square, circular, octagonal, or other shape, to include all cutting and waste; bases and caps for pillars, giving size, to be kept separate, per ft. super.

Beams—(To be measured as girth of beam from underside of floor slab only, "including all labours"; state if radiating or circular on plan or elevation, including mitres), per ft. super.

Roofs.—Flat, raking, segmental, semicircular or elliptical (measure both sides if over 30 degrees slope), per sq.

Return Edges of Openings in walls, floors, or roofs, per ft. run.

Soffits of Stairs—Raking, flewing or circular on plan (to be described as including cutting and waste), per sq.

Mouldings—Over 12 ins. girth, per ft. super.

Ditto—12 ins. girth and under, per ft. run.

Mitres, Stopped Ends, Etc., each.

Return Edges of Concrete Floors, Strings and Risers of Stairs, per ft. run.

Circular or Raking Cutting and Waste to be measured to all irregular surfaces of walls, floors and roofs, per ft. run.

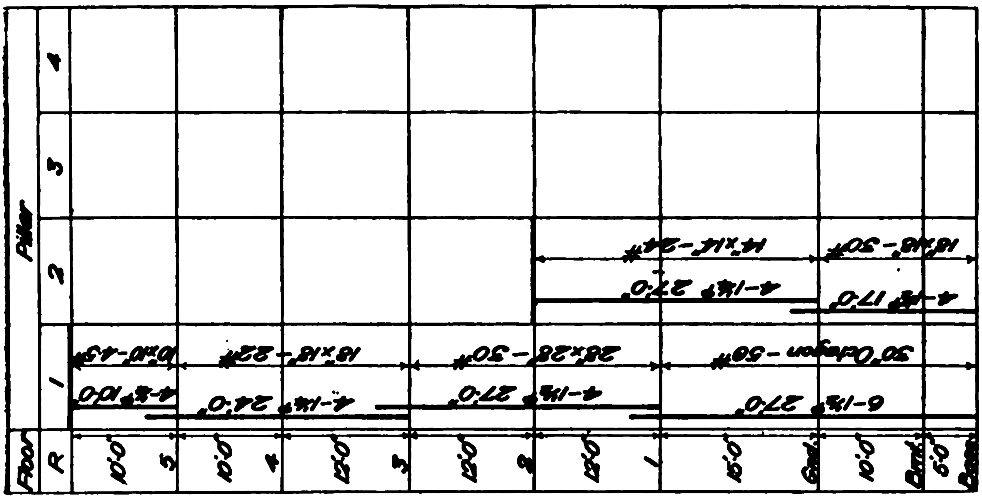
Key Blocks, Consoles, Etc., giving full size and description, each.

Splays, Chamfers, Rebates, Rounded Angles, Etc., to be described as including fillets and moulds, per ft. run.

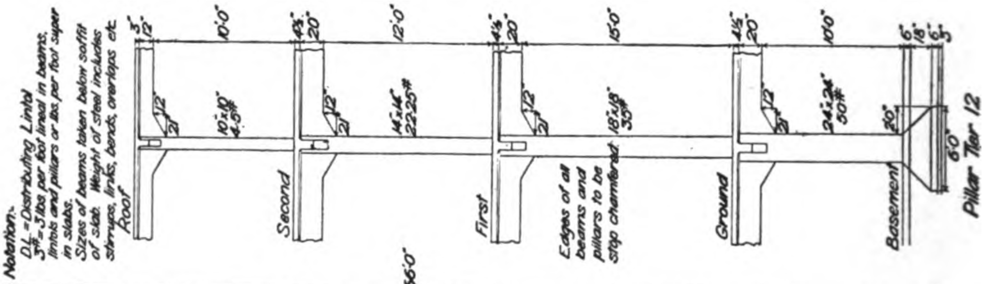
REINFORCEMENT.

Ordinary steel bars from ½ in. to 2 ins. diameter may be included under one heading (stating the diameters). Bars under ½ in. and over 2 ins. in diameter to be kept separate. Bars over 30 ft. long to be kept separate.

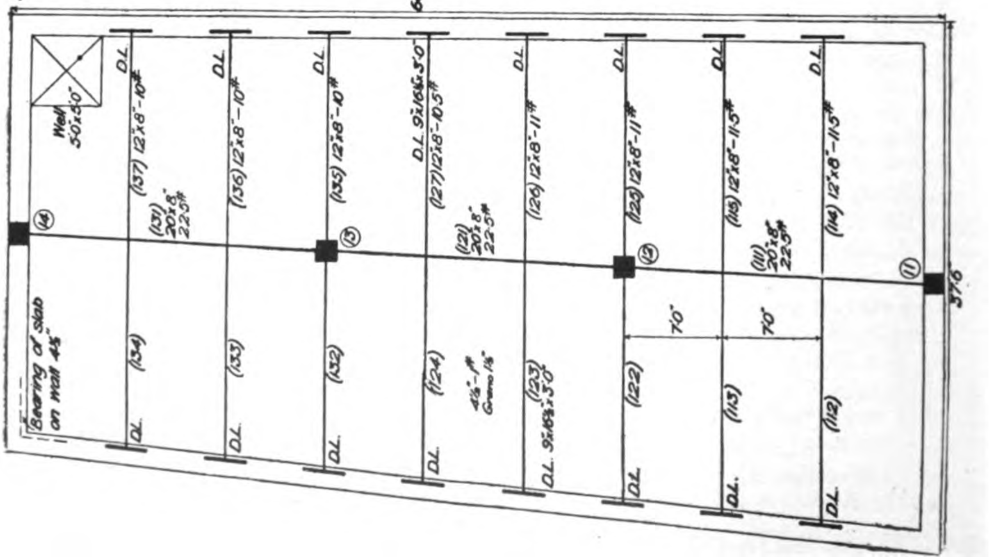
All wire ties (exclusive of helical or horizontal binding or stirrups) to be included in the description of the reinforcement.



Pillar Schedule.


Notation:-
D.L.=Distributing Lintel
3#=3 lbs per foot lineal in beams, lintels and pillars or lbs per foot super in slabs.
Sizes of beams taken below soffit of slab. Weight of steel includes stirrups, links, bends, overlaps etc.
Roof
Second
First
Ground
Basement
Edges of all beams and pillars to be stop chamfered.
10"x10" 4.5#
14"x14" 22.25#
18"x18" 33#
24"x24" 50#
12
21
30"
6'0"
5"
12"
10'0"
4½"
20"
12'0"
15'0"
10'0"
6"
18"
Pillar Tier 12

Typical Pillar detail.



Ground Floor Plan.—Beam Schedule

The different items of reinforcement to be kept separate as described for "Concrete" and "Centering, Shuttering, etc."

STEEL BARS—State "including all bends, hooked ends, etc., and fixing at any level, in any position," per cwt.

STIRRUPS AND BINDING—Horizontal or helical, per cwt.

MESHWORK REINFORCEMENT supplied in sheets or rolls—to be measured "net" (*i.e.*, no allowance made in the measurement for laps or for straight cutting and waste), including all labours for bending, etc., per yd. super.

Raking and circular cutting and waste to ditto, per ft. run.

A draft report was also presented by the Reinforced Concrete Practice Standing Committee recommending that a standard tabulated form for preparing quantities for reinforced concrete work be adopted. The Committee submitted a form with headings for consideration and discussion.

DISCUSSION.

Mr. George Corderoy, Assoc.Inst.C.E., stated that with regard to reinforced concrete they were happily not hampered with any ancient customs of measurement. Nevertheless, he thought that if they left out any of the ancient practices in preparing a bill of quantities, unless they were careful to safeguard themselves in some way, they gave opportunities for claims for payment on the score of custom. He regretted that the Committee had not the full courage of their convictions to adhere to the foot unit for centering and shuttering for foundations and walls. There was really no merit in the term "square" as applied to a great many items of foundation work, and the term "foot" was very often used for centering. He gathered that the guiding principle of the surveyors who had drafted the Report had been that which had practically governed the preparation of ordinary quantities, namely, that no manufacturing labours were included, but only fixing labours.

In conclusion, he moved that the first recommendation should read, "That the method of measurement as compiled by your representatives and as copy enclosed be recommended for adoption by surveyors practising in measuring, and quantity surveyors, signed by the signatory bodies," etc., thus making the resolution recommendatory and not mandatory.

Mr. G. C. Workman agreed with Mr. Corderoy that it would have been better to have kept to the square foot in centering, shuttering, etc., for foundations and walls. He understood that the reason for the adoption of the square was that contractors were in the habit of buying their timber by the square. He thought that a medium might be found between the square and the square foot; the square was too large, and the square foot was too small. That would apply also to floor slabs, roofs and soffits of stairs.

Mr. Alan Paull, F.S.I., suggested that, as bases and caps for pillars were of various sizes, if kept separate, as recommended by the Committee, it would lead to a lengthening of the bill. He further suggested they should omit the words "giving size," and substitute "in so many," in connection with the measurements of pillars. He supported the Committee's adoption of the square as against the foot because it showed that a large quantity was being dealt with.

Mr. Bylander pointed out that it was only intended that the bases and shuttering should be kept separate from the body of the column or shaft.

Mr. F. E. Wentworth Sheilds, M.Inst.C.E., thought that it would be well to standardise as to whether the driving of piles should be charged as a separate item from the making of them. He noticed that the Committee had ingeniously got over the difficulty of having six different names for shuttering by inventing a new one. He suggested that, instead of coining a new word, which was always difficult to popularise, they should adopt the American term "False Work," which covered all the Committee meant to convey. He inquired whether it would not be well, when describing the floor slabs under centering and shuttering, to state that the price should include temporary props?

Mr. P. F. Gleed, F.S.I., thought that their object as surveyors in preparing bills of quantities was to give the contractor such information as would enable him readily to obtain a correct value of the contract to be executed, and they should do that irrespective of the amount of trouble it caused themselves. He thought it ought to be cleared up in considering the suggestions before them—whether the Concrete Institute represented professional engineers or contracting engineers.

Mr. W. E. Davis felt that there was a good deal in the suggestion that the use of the square as a unit in regard to shuttering for foundations, vertical, splayed or circular, was rather a large order. The question of pile driving was a most complicated matter for a quantity surveyor to deal with, and he was sorry that the Committee had not tackled it. He thought that the diagram which the Committee had prepared would be of immense value to quantity surveyors.

Mr. G. M. Nicholson, F.S.I., seconded Mr. Corderoy's amendment. He agreed with Mr. Davis that it would be a benefit if some suggestion were given for dealing with concrete piles, as the latter could hardly be considered the same as pillars. It would be an improvement to the report if they could have some guide as to the measurement of concrete piles and the driving of them.

Mr. Alban H. Scott, M S.A., who had been prevented from attending the deliberations of the Committee, was sorry to find himself at cross-purposes with some of the recommendations. He had yet to learn that it was only engineers who had to deal with designs for reinforced concrete. He ventured to suggest that, in dealing with concrete roofs, no district surveyor would allow concrete to be worked with only single centering for a slope of over 30 deg. He had never carried out work of this kind with more than a 25 deg. slope, and too much risk was being run at that; 18 deg., he thought, was the limit. It was a pity that they had not asked the opinion of the London Master Builders' Association and the R.I.B.A. before they issued the report. He suggested that in the L.C.C. Regulations there were a lot of good definitions for the various terms employed in the work, especially for centering, and he thought that much of the discussion that evening would have been avoided if the Committee had adopted the terms used in the L.C.C. definitions.

Mr. R. Graham Keevill, A.M.I.Mech.E., suggested that pile work should be classified under two heads, cutting and driving, and moulding. Included in the price for driving should be given the cost of scantling. Cylinder work did not appear to have been dealt with, and perhaps the Committee, in elaborating their report, would deal with the question. He presumed that the form given would take into account the beamless floor, which seemed to be a thing of the future. Although America appeared to have a monopoly of it at the present time, there was a possibility of this becoming a standard thing in this country in the future.

Mr. E. Fiander Etchells, F.Phys.Soc. (Chairman of the Science Standing Committee, C.I.), said their one aim was simplicity. They would always have difficulties until it was made clear whether form work included strutting, and whether centering included sheeting. They were building up a terminology for a comparatively new subject, and it was their duty to build foundations in such a manner that those who came after them would be able to take them down.

Centering, using the word in its widest sense, comprised three kinds of timber—sheeting, battens, and strutting, and they wanted some term to cover the three. After an exhaustive investigation of all available text-books, it was found that the majority of persons used the term centering. He thought that there was considerable misapprehension as to the derivation of the word "centering," many people being of opinion that it was an Americanism. The word "center" was derived from an old French word, meaning the timber work used for supporting a structure during its erection. It so happened that structures which most required support during erection were arches, some of which had one centre and others three.

The point had been raised as to whether the members of that Institute were professional engineers or contracting engineers. It was rather a difficult question to answer, but they had examined themselves and found that five-sixths of them were called professional engineers, and one-sixth specialist engineers.

Whether they decided in favour of the term "form work" or "centering," it would be advisable to ask the Local Government Board to adopt that word, as the Regulations had now left the hands of the County Council, and were now under the consideration of the Board.

Although they were a specialist society, he thought it was advisable that their report should be recommendatory rather than mandatory, because they were the youngest specialist institution and ought not to dictate to older societies. It was a question as to whether anyone was competent to lay down a rule for another authority in matters where public interests were not concerned; moreover, as there was no penalty attached, they could not enforce regulations which they sought to impose.

Mr. Percival M. Fraser, A.R I B A., agreed with the observations of Mr. Alban Scott. He knew what the opinion of the Builders' Association would be. An expert estimating clerk would put his pen through all this and ask for three items. He strongly deprecated the reduction of the units from yards cube to feet cube, which entailed very great labour and greater risk of error. It was ridiculous to measure piles so much per yard cube for the concrete, including driving.

Mr. T. J. Carless, President of the Quantity Surveyors' Association, had great pleasure in supporting the report of the Joint Committee, and thought that the President of the Concrete Institute would be quite willing to accept Mr. Corderoy's suggestion. Personally, he was not altogether in accord with the opinion of the majority of the members of the Council of his Association. He did not see the necessity for keeping the work on each floor separate; builders whom he had consulted did not want it : they might just as well keep the brickwork to every floor separate. As an individual, he thought that the same unit was not applicable for all classes of work, although his Institute had agreed to the foot cube unit. The unit should suit the work, and the work should not be made to conform to the unit.

Mr. A. G. Cross, F.S.I., said he could not agree with Mr. Workman's suggestion, because, by using a square the decimal unit was maintained, but the objection of having too many figures for one column was overcome.

He agreed with Mr. Alan Paull that the words, "giving sizes," in connection with bases and caps for pillars, was superfluous.

In reply to a question of Mr. Gleed's, he thought that keeping the work on each floor separate cleared up the question of hoisting, and did not involve the surveyor in very much additional work.

As to Mr. Davis's objection to the measurement of floors by the foot cube, Mr. Cross said that most of the Committee were of the same opinion, but they eventually came to the conclusion that one unit for the whole was desirable, and any other unit for beams and pillars seemed to be out of the question.

Mr. Alban Scott had asked that the R.I.B.A. should be consulted. They had consulted the R.I.B.A., and that body had no opinion on the question of a standard system of measurement.

Mr. Cross concluded by expressing the hope that the final report of the Committee, after effect had been given to the various suggestions made that night, would be adopted.

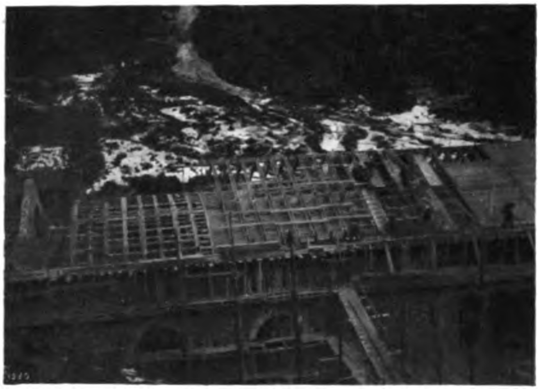


Fig. 1. Reinforced Concrete Roof of Power House in course of construction.

REINFORCED CONCRETE AT THE CENTRAL ARNO HYDRO-ELECTRIC STATION, CEDEGOLO, ITALY.

An interesting instance of reinforced concrete work in connection with a hydro-electric station is that of the Central Arno Station at Cedegolo, erected for Messrs. Adamello. There are various features in this work which are worthy of study. The work was carried out to the designs and under the supervision of Messrs. Damioli Bros., of Milan, to whom we are indebted for our particulars and illustrations.—ED.

THERE is some interesting reinforced concrete construction in connection with the hydro-electric station recently erected in Italy and known as the Central Arno Station, and although the methods of design are somewhat different from those employed in this country, there are several points worthy of notice, particularly so as regards the design of the retaining wall or dam surrounding the large reservoir or basin from which the hydraulic power is derived.

The building forming the power house is over 200 ft. long and about 48 ft. wide, and is a one-story building with outer walls of brick and stone roofed with reinforced concrete arched trusses. These trusses have principal rafters 10 in. by 5 in. reinforced with four bars in the lower surface and these are inclined in the ordinary way and support panels of hollow bricks which are put together with a keyed joint and to which the tiling is attached. A horizontal tie beam, 10 in. by 8 in., reinforced with four rods in the lower surface and two in the upper, connects the ends of the rafters, and in addition to this a curved beam is formed which connects with the same points and rises about 8 ft. 6 in. above the tie beam. This curved beam is 12 in. deep by 5 in. wide and is reinforced with two bars in both upper and lower surfaces, while the ceiling over the apartment is formed at this level and follows the same curve, this being also constructed with hollow bricks having a keyed joint. An inclined strut connects the rafters and tie beams at the junction of the former with the arched beams and this is 8 in. by 5 in. with one rod in each corner. The bearing for the trusses is provided by the mass of reinforced concrete formed at the junction with the wall, where the eaves project a distance of about 35 in. from the face of the wall, this portion being also in reinforced concrete, the bars being continued outward from the tie beams and hooked down. Various stirrups and ties are provided at intervals to all the members and the bars in the rafters are cranked up where passing over the strut to provide continuity. Some idea of the magnitude of the work and the timbering required can be gathered from the photographic views in *Figs.* 1 and 2, which were taken during progress, while the exterior view of the completed building is shown in *Fig.* 4.

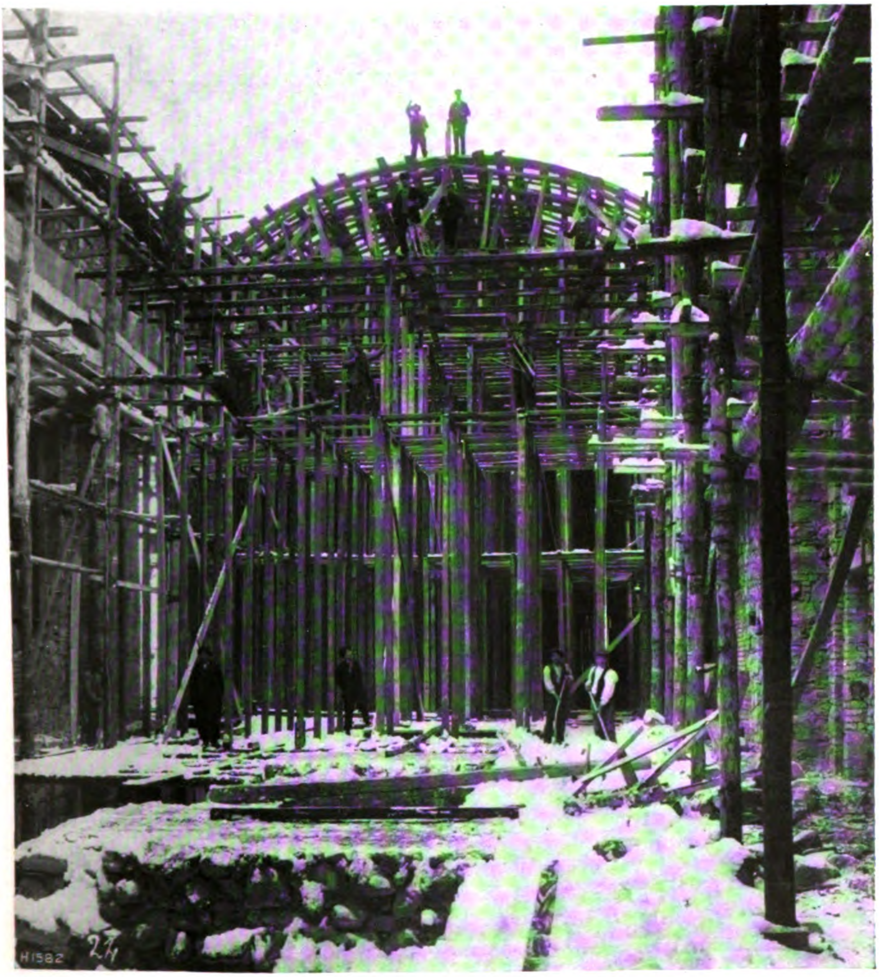


Fig. 2. Power House in course of construction.

THE CENTRAL ARNO HYDRO-ELECTRIC STATION AT CEDEGOLO, ITALY.

The water basin has an irregular-shaped plan, with a maximum length of about 190 ft. and a maximum width of about 150 ft., in addition to the valve chambers, etc., which are constructed at one end. The total height of the dam surrounding the basin is about 25 ft., and it is not constructed in the usual manner with an ordinary single wall, but is built with inner and outer divisions, which are connected by horizontal and vertical slabs and beams, as shown in

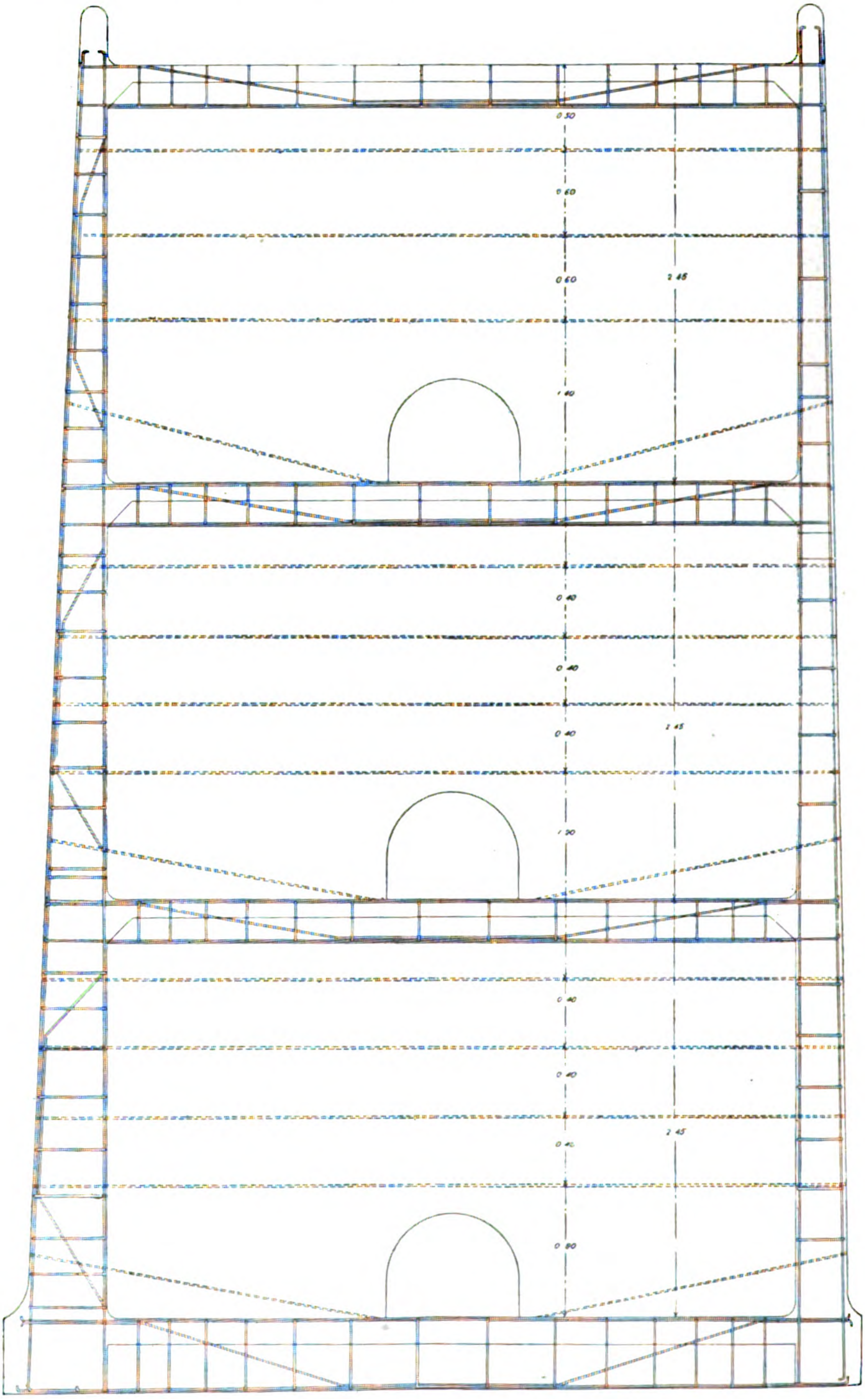


Fig. 3. Transverse Section of Reinforced Concrete Dam.
THE CENTRAL ARNO HYDRO-ELECTRIC STATION AT CEDEGOLO, ITALY.

the drawing in *Fig*. 3. The outside width of these two divisions is about 16 ft., and the thickness at the base of each division is 12 in., with a reduction to 6in. thick at the top. Reinforcement is provided in both inner and outer surfaces, with stirrups or links connecting the two sets of rods; while the space between the two divisions is divided up into three compartments by the horizontal divisions, and the foundation is formed by a connecting slab 10 in. thick and beams 16 in. deep, coincident with the vertical stiffening transverse walls.

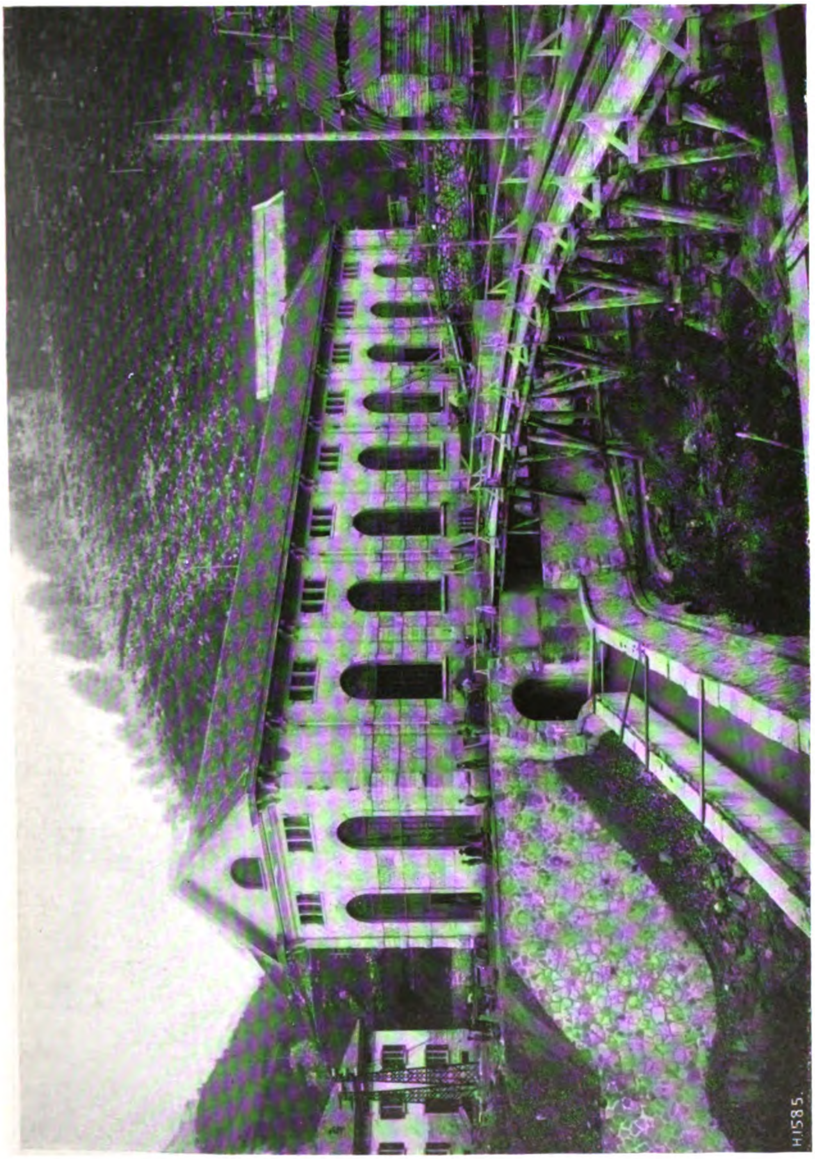


Fig. 4. View of Completed Power House.
The Central Arno Hydro-Electric Station at Cedegolo, Italy

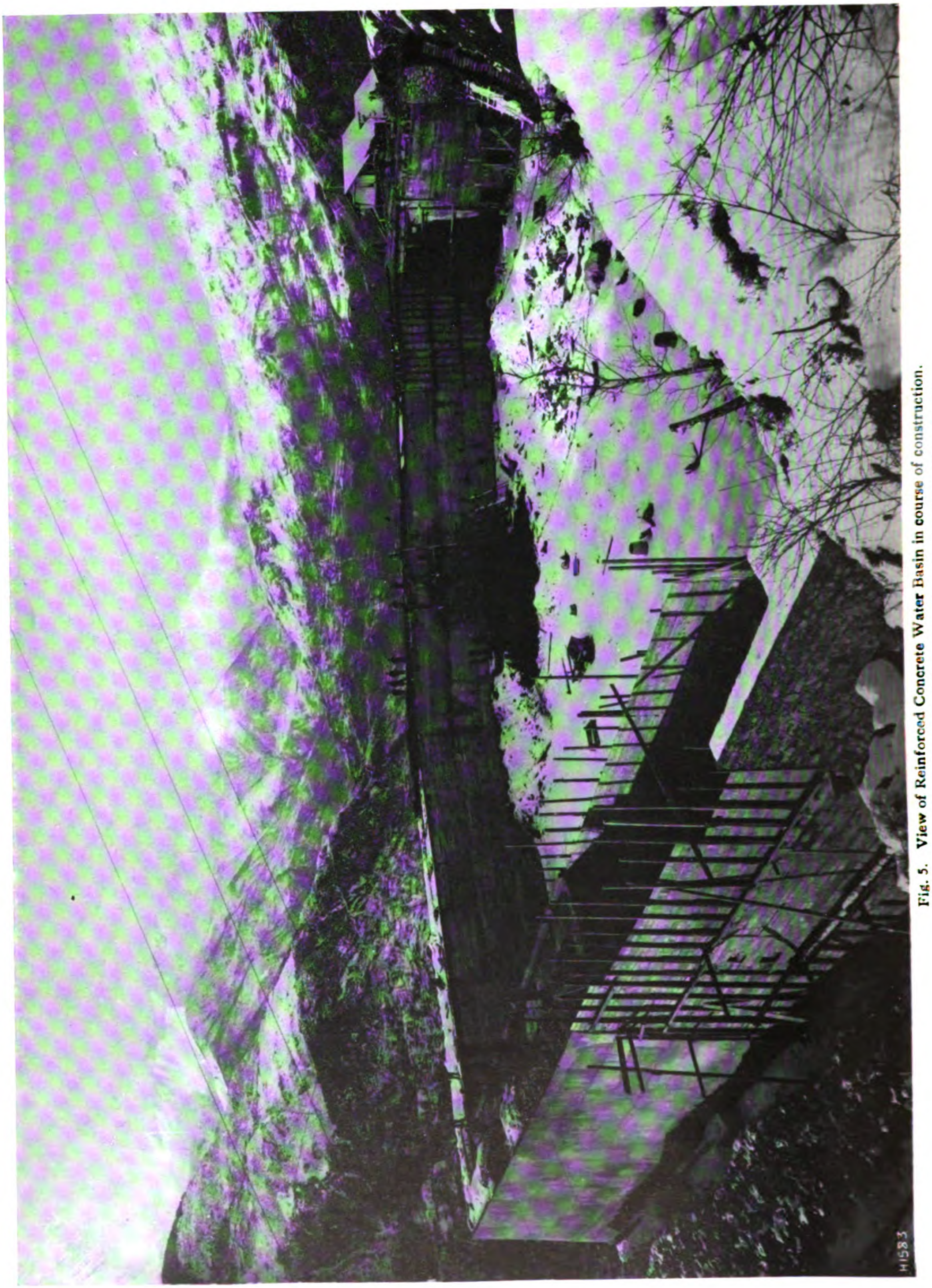


Fig. 5. **View of Reinforced Concrete Water Basin in course** of construction.
THE CENTRAL ARNO HYDRO-ELECTRIC STATION AT CEDEGOLO, ITALY.

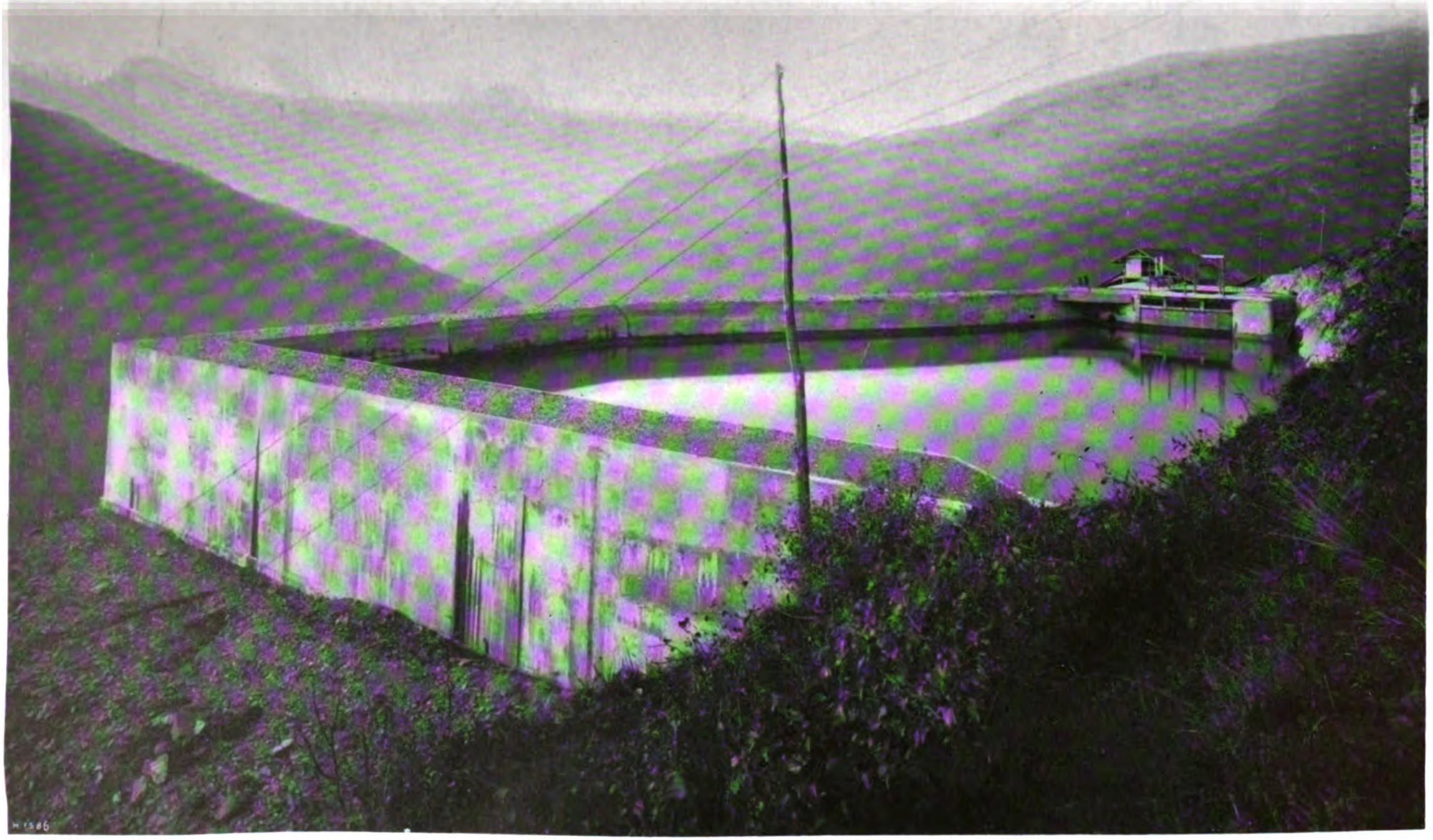


Fig. 6. View of Completed Reinforced Concrete Water Basin.
THE CENTRAL ARNO HYDRO-ELECTRIC STATION AT CEDEGOLO, ITALY.

The horizontal divisions are constructed with reinforced slabs 4 in. thick and reinforced concrete beams 10 in. thick, the junction of the slab and wall being strengthened by forming haunches which extend down to a level with the inside of the beams. The vertical division walls, which also serve to tie the outside walls together, are spaced at intervals of about 10 ft. 6 in., and semi-circular headed openings are formed in these to connect the whole of the compartments and allow the water to flow through. The interior is communicated with the basin itself, and consequently the whole of the space between the inner and outer walls of the dam is filled with water, and the weight of this water is added to the weight of the dam itself, and serves the purpose of increasing the resisting moment of the whole structure. It is claimed that a dam of this design can safely retain a volume of 15 per cent. more water than a masonry dam occupying the same space, and it certainly forms an efficient and unique example of construction of its kind. The disposition of the reinforcement generally can be gathered from the drawing, and need not be further described here. A view of the work during construction can be seen in *Fig.* 5, this showing the two division walls nearly complete and the interior of the basin; and the finished basin is shown in *Fig.* 6, with the water filled into same. Some idea of the plan can also be gathered from this photograph, and the valve chambers can be seen in the distance. The top of the wall is filled in and forms a convenient walking way around the basin.

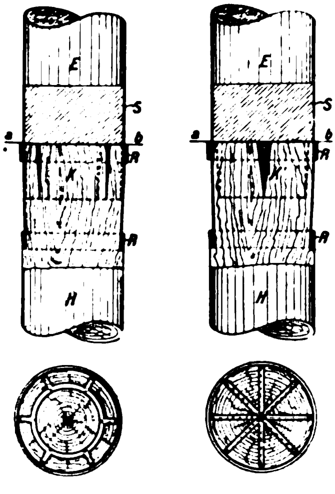
The example is worthy of study by engineers, as it exhibits a thoroughness of design to suit the special requirements of the case which is creditable.

THE HEIMBACH SYSTEM OF COMBINED WOOD AND REINFORCED CONCRETE PILES AND OF LENGTHENING WOODEN PILES.

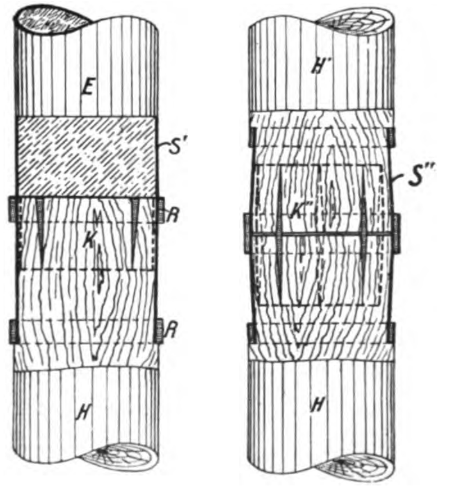
By PROF. DR. SCHÖNHÖFER, Brunswick.

This journal frequently reviews interesting technical information as to new inventions, and the information being presented as a rule by the inventor or his agents is necessarily ex parte and frequently of a debatable character. It is extremely difficult, in such statements that are presented, for us to draw the line as to where commercial optimism ends and general technical interest commences. In the following article, presented to us by Professor Schönhöfer, of Brunswick, and dealing with an Austrian invention, a notable instance is presented where we think the scientific aspect claims attention, and although some of the statements contained in this article are not only ex parte but very controversial, we have published this contribution as one that may lead to discussion in our columns.—ED.

THE wooden pile, used for many centuries, has been largely replaced in recent times by the reinforced concrete pile. Reinforced concrete piles are everywhere more advantageous—where wooden piles would be destroyed by water, or where, on account of the great lengths required, they would be too costly or unobtainable.



Figs. 1 and 2.



Figs. 3 and 4.

SHOWING METHOD OF CONSTRUCTING PILES.

Mr. Heimbach, of Bregenz, Austria, has ingeniously succeeded, first in combining the wood and reinforced concrete pile, and next in rigidly uniting two or more wooden piles. In this way a combined pile has been constructed, uniting the advantages of both systems, and independent of the depth of the ground water; whilst, lastly, the difficult problem of the lengthening of the wooden pile has been solved, so that wooden piles may be obtained of any length.

The combined pile is prepared as follows: A wooden pile, provided with a broad ring at the head (*Fig.* 1) is driven in the ordinary way until the head is about a metre above the surface. The ring is then removed and replaced by a steel tube, S, made conical below, and forced over the cylindrical end of the pile. A steel annular wedge with radial ribs (*Fig.* 5) is then placed on the pile and driven home. This expands the upper part of the pile until it makes a firm and watertight joint with the conical head. The steel tube is strengthened by one or more protecting rings, R. Lastly, the steel reinforcement is placed in the tube, which is then filled with concrete, E. If the thickness of the tube be sufficient, special reinforcement may be dispensed with.

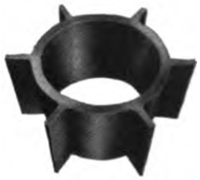


FIG. 5.
ANNULAR WEDGE WITH RADIAL RIBS.

In place of the annular wedge a conical wedge with radial ribs, K′, may be used (*Fig.* 2). Also a cylindrical steel tube may be used in place of a conical one, but in that case the protecting rings must be somewhat thicker (*Fig.* 3).

A wooden pile is lengthened by using, in place of the simple conical tube, one with two conical ends, placed over the top of the pile (*Fig.* 4). A double annular wedge K″, is then placed on the wood and the second pile, H′, with a cylindrical end, is then driven into the open end of the tube. The ramming causes the wedge to enter the ends of both the wooden piles, and by fitting tightly into the tubes to make a tight joint.

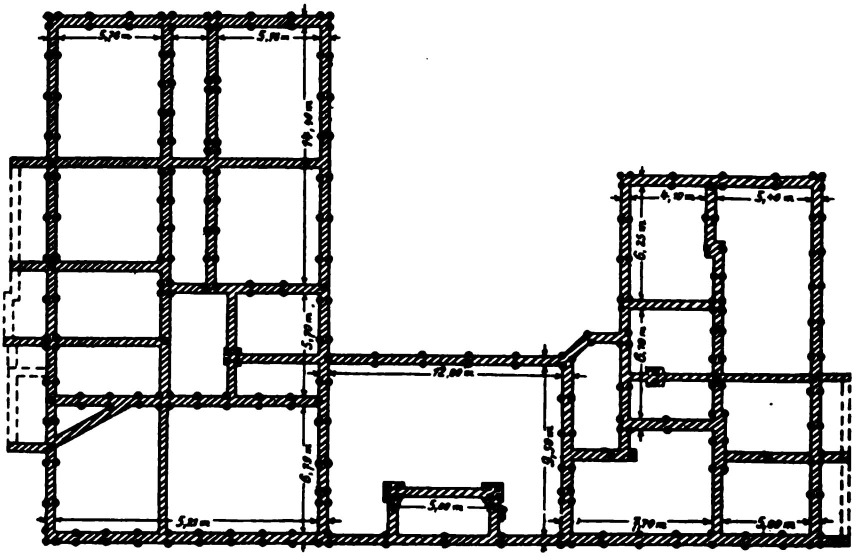


FIG. 6. PLAN OF BUILDING AT LINDAU.

The Heimbach compound piles and method of lengthening have been employed in many constructions. The firm of Heimbach and Schneider, of Bregenz and Lindau, have employed them with success in many buildings. This firm owns the patents in all countries. *Fig.* 6 shows the plan of such a building at Lindau. *Fig* 8 is a general view, and *Fig.* 7 shows a detail of the construction. The two new systems of piling were also exhibited at the International Building Exhibition in Leipzig, attracting much attention and obtaining the gold medal of the City of Leipzig.

The combined wood and reinforced concrete pile gives all the advantages of a deep foundation, especially those of avoiding deep excavations and costly dams. The manufacture is simple, and special preliminary work is unnecessary. The costly equipment for the bending of reinforcing rods, erection of shuttering, etc., necessary for reinforced concrete piles, is avoided. Ramming may be begun at once, and the operation proceeds rapidly and continuously, using the ordinary pile-rammer. The special rams and frames used for reinforced concrete piles are not required. This is particularly of advantage where the earth is very soft, as the great weight of special pile-rammers is then a disadvantage.

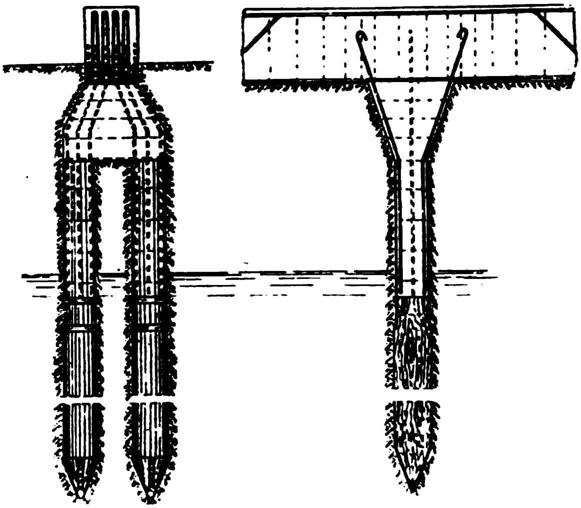


Fig. 7. Showing Detail of Construction.

The vibration in ramming is not excessive, which is an advantage where the work is near to dwelling-houses or structures the safety of which is endangered.

The combined wood and reinforced concrete pile is independent of the level of water or ground-water, provided that the wooden part is at a sufficient depth. It is also of advantage in soils or waters which destroy concrete. This is the case with boggy and peaty soils, containing humic acids, with waters containing calcium sulphate or magnesium salts, sea water, or industrial waste waters containing acids. Wood is not attacked by any of these substances, and the concrete is protected by the steel tube, and, on account of the water-tight connection, cannot be reached by water. The steel tube may be protected by paint or by a metallic coating.

The load-carrying power of the combined pile is great, and especially in soft, muddy or peaty ground is large in comparison with reinforced concrete piles, as the wooden part becomes tightly fixed in the earth and increases in load-carrying powers with time.

The combined pile is specially suited to the foundations of reinforced concrete buildings, as the sole-plate of such buildings is naturally much more easily attached to the reinforced concrete part of such piles than to the heads of ordinary wooden piles. It is also suited to marine work, as the wood embedded in the earth is protected from boring molluscs, whilst the concrete is protected from sea water.

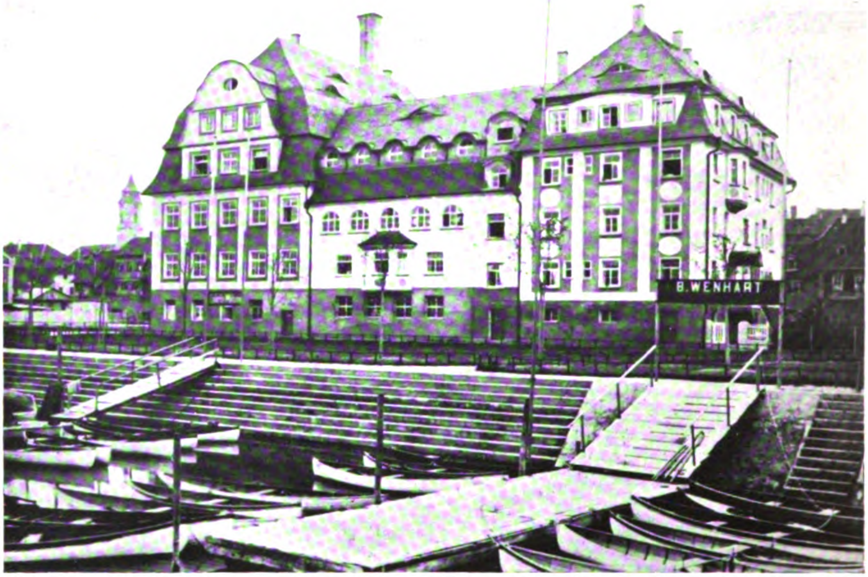
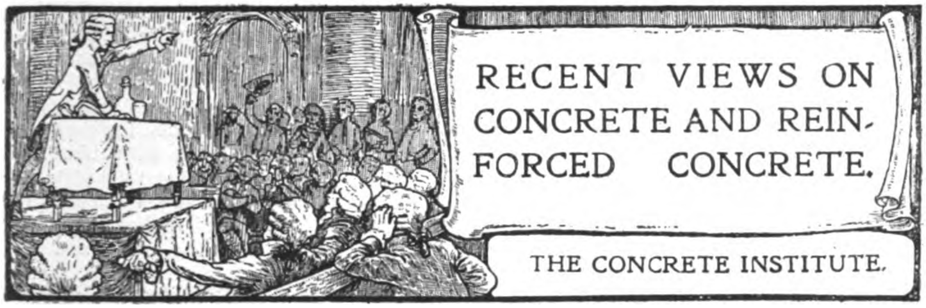


FIG. 8. GENERAL VIEW OF BUILDING AT LINDAU.

This system of piling is cheap, as the embedded portion is of wood, and only the comparatively short upper part is of the more costly reinforced concrete.

The Heimbach method of lengthening piles has also many advantages, being available where, on account of the length required, single wooden piles would be too costly or even unobtainable. This is particularly the case with marine landing stages, where wooden piles are necessary on account of their elasticity, whilst they have also to be of great length. The union of the two piles is not only rigid, but highly elastic, so that the combined pile is fully equivalent to a single pile.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

FACTORY CONSTRUCTION.

By PERCIVAL M. FRASER, A.R.I.B.A.

The following is an abstract from a paper read at the Forty-second Ordinary General Meeting of the Concrete Institute. The lecturer illustrated his paper by numerous interesting slides.

INTRODUCTION.

It is now generally recognised that a well-equipped series of shops is an absolutely essential factor in a successful industrial concern.

It cannot be denied that English factory buildings, whether in reinforced concrete or otherwise, cannot bear comparison with similar buildings abroad, especially in America. That English factory buildings, even with the most enterprising and successful firms, are often disgraceful, no one who has had any experience in our great manufacturing centres can deny.

The attempted adaptation of groups of buildings to a use foreign to that for which they were designed is one explanation of the grotesque jumble of nondescript buildings dignified by the name of industrial buildings which we so often see.

It is also true that in the majority of cases economy could have been effected had the old buildings been scrapped and an entirely new series of buildings erected. I seriously suggest that the English factory owner requires educating in such matters as this, and that he has a great deal to learn from the United States on such points.

The relations of the architect and the engineer who is dealing with the lay-out of the plan or who is running the process of manufacture should be very close.

Some of the reinforced concrete specialists make a point of preparing complete designs for factories and other buildings, concerning which they can have absolutely no experience or knowledge, and this is a further prolific source of ill-designed and inefficient factory premises.

There is a great deal that is incongruous in our industrial works. A typical English power plant represents the finest product of human workmanship, and the employees, from the chief engineer to the humblest stoker, take a pride in keeping it at its highest pitch of efficiency and scrupulously clean, for to their mechanical minds it is a thing of beauty; but this is ordinarily housed without scruple in a corrugated iron building, which is not only an eyesore but totally incapable of efficiently protecting the expensive machinery it contains.

NOTES ON THE DESIGN OF INDUSTRIAL BUILDINGS.

The governing principle in the design of industrial works is to provide efficient buildings at the lowest cost. A certain operation takes place in each department, and these processes are components of the finished article for the manufacture of which the buildings are erected. Each building unit, therefore, must be designed to allow its particular process to be carried out under the best conditions and without restrictions, and the buildings as a whole must be schemed to allow the various processes to pass through them in the most direct manner without loss of time or waste in any shape or form. The difficulties and restrictions of a building site must be courageously dealt with, and are frequently put to valuable use; such as, for instance, difficulties in the levels of a building site may be frequently utilised to convey the material by gravitation through the various departments and thus reduce handling and power consumption, and again will often enable loading stages to be formed at convenient heights.

The effect of well-constructed, light, and healthy buildings on the health and spirits of the workpeople is an important factor.

Among the questions which frequently come before an architect in designing industrial buildings is the following: Whether the building as a whole should be one story or more in height. Unless the foundations are likely to prove abnormally expensive it will generally be found that the one-story building can be constructed the more cheaply.

A second important detail which practically always arises is the question of eliminating columns or reducing their number and planning their positions to the best effect.

Other questions which must infallibly arise are the nature of the lighting, which must, for many manufactures, be from the roof. In two-story buildings the width of the building is determined hereby, but it is an advantage to make the upper floor with roof light. Too much daylight, unlike artificial light, cannot be provided, but the increase of window space will add to cost and complicate heating and ventilation. The north or sawtooth roof is always an advantage, but is not always worth the expense, costing as it does 10 per cent. more than an ordinary pitched roof in steel, or 20 per cent. more than a flat roof in reinforced concrete.

With regard to the clear height of workrooms, a margin should be allowed over the bare necessity.

The number and disposition of floor beams is often dictated by the needs of economical design, but frequently one has to provide floorslabs free from beams to increase headroom or for other reasons.

In dealing with the advantages and disadvantages of reinforced concrete for factory construction in comparison with the prevailing methods of construction, the following points must be considered.

There are, of course, three attributes of every marketable commodity—namely, goodness, badness, and indifference. A casual examination will show that reinforced concrete will be adaptable and suitable for factory construction. We have, therefore, to weigh the special advantages that it possesses with the disadvantages, and decide whether the advantages are such that it is as good as other methods of construction at the same or less cost.

The serious competitors of reinforced concrete which are at present before the building world are as follows:—

Brick, steel and cast-iron, wood, sheet-iron and metal lathing and plastering, tiling, terra-cotta or similar slabbing and casing, and a number of patent forms of construction too numerous to mention and most difficult to classify, most of which, however, come within the scope of reinforced concrete in one or more respects.

It is exceedingly difficult, if not impossible, to definitely pronounce on the comparative economics of the foregoing materials, and we can only take specific instances and endeavour to generalise from these. I am able to give a case where competitive prices were obtained for a building, which is of a fair size, straightforward, and a really useful one for this comparison. In this case alternative schemes were prepared in the fullest detail and competitive prices obtained. The results were as follows:—

1. For a steel-frame building with brick walls, corrugated iron roof (two-thirds north light), wood joists and boards on steel bearers to galleries, and patent glazing to roofs, the cost was 100 per cent.

2. For a reinforced concrete building with roofs as last, 92 per cent.

3. As last, but with concrete roofs, part flat, part with north lantern lights, but with brick panel walls 89 per cent.

4. As No. 1, but with corrugated iron walls, 89 per cent.
5. Wholly in reinforced concrete, 88 per cent.

The building was actually carried out in reinforced concrete, including the gutters, down pipes, roofs, walls, foundations, and every detail where it was possible for this material to be used. In this case there were no special circumstances whatsoever in favour of reinforced concrete; indeed, the question of the supply of aggregate was a very difficult one, as it had to be brought from twenty-five to thirty miles by rail. The foregoing figures will apply to all cases of ordinary buildings costing more than, say, £2,000. A building of less cost will, generally speaking, be found cheaper in some other form of construction, and walls will nearly always be found cheaper in brick panels than in concrete slabs.

MAINTENANCE.

The freedom of concrete from deterioration permits of savings in maintenance charges. These are exceedingly great in large series of factory buildings, and can never be shown on paper. Maintenance means more than merely guarding against the ravages of time. The necessity for maintenance implies decay; the maintenance costs are a dead loss, and maintenance is in itself a thankless job owing to the fact that it is simply patched-up work, merely staving off the inevitable, which every year becomes at once more onerous and more useless.

Considering the claims of reinforced concrete, without wishing to be unduly enthusiastic, it may be reasonably asserted that, after a lengthy trial and the closest scrutiny of our chemists, architects, engineers, and constructors, reinforced concrete is, practically speaking, free from depreciation if constructed according to the latest approved practice.

Concrete constructions carried out during the Roman Empire are completely sound to-day after a period of two thousand years entirely without maintenance. As regards thoroughness of construction and the quality of materials, the Roman constructions cannot compare with the modern. This simple truth needs to be emphasised because the public are apt to draw odious comparisons between the Pyramids of Egypt and the modern suburban villa, without reflecting that the comparison is wholly unjust and grotesque.

Even with rigid economy factory construction in concrete is, if conscientiously carried out, better constructed to-day, and therefore more permanent than any work constructed by the ancients.

In reinforced concrete we have found one of the few suitable materials for the prevailing climate of Northern Europe.

FIRE-RESISTING PROPERTIES.

The fire-resisting properties of various forms of construction are of paramount importance in factory buildings. The effect of fire-resisting construction in reducing insurance premiums is but a small matter compared with the damage which ensues to a business owing to the extreme dislocation caused by a fire, which no insurance can ever cover; for we have to consider the financial loss in the shape of buildings, plant, and machinery ruined, the destruction of office documents which cannot be replaced, and the permanent loss of many skilled workmen who are thrown temporarily out of work, and the occasional terrible loss of life. The output of a firm is, moreover, temporarily paralysed, the normal trend of business is disorganised for a considerable period, and the eventual effect is that the insurance company will not reinsure at the same rates.

Timber construction according to English methods is not only rapidly destroyed by fire but acts as fuel. Steel joists and cast-iron structural members are liable to immediate failure, and owing to the distortion in expansion and contraction will throw down walls which with a timber construction would have remained sound and repairable after the fire.

Steelwork can be effectively cased with respect to stanchions and columns, but it cannot be said that a really efficient means of casing beams has yet been found, and in any case such protection is expensive and clumsy.

Nothing is, of course, fireproof, but we have to seek for the nearest approach to this ideal. Ordinary reinforced concrete construction is as efficient a fire resister as can be found. The metal is naturally guarded against by the concrete covering. There is nothing combustible about the construction; it is not liable to exercise a dangerous thrusting or overturning action, even when heated and suddenly cooled. It is of course liable when quenched with a strong shower of cold water to have the covering of slabs and beams either flake off or disintegrate. It is rarely or never found that any of the concrete, beyond the covering to the reinforcement, suffers any irreparable damage. Any such covering can be broken away where loose and the building restored after the conflagration. It can therefore be fairly claimed that for factory construction which requires a high standard of fire resistance reinforced concrete can rival any other comparable method of construction.

The fire insurance companies have been quick to recognise the use of reinforced concrete as a building material for factory construction.

It will be noticed that their rules are very sound and practical. They are framed to be applied in an honest and liberal manner, and are altogether in great contrast to the usual official notices of this nature. The only criticism to be offered is, that although they allow floor slabs to be 5 in. thick, and roof slabs 3 in. thick, they ask for external walls 6 in., partition walls 8 in., and party walls 13 in.

The Rules read as follows:—

RULES
AS TO
FERRO-CONCRETE OR REINFORCED CONCRETE CONSTRUCTION
Issued by the Fire Office Committee.

"Buildings constructed with concrete, reinforced in every part with embedded metal rods or bars spaced not more than 12 in. apart, securely connected or overlapping at least 6 in. at all abutments and intersections, having also bands or bars across the thickness of the concrete, may be deemed as Standard II. Construction, provided they conform to the above rules for ordinary brick and steel construction, with the following modifications:—

> "Concrete may be composed of sand and gravel that will pass through a ¾-in. mesh, or of the other materials mentioned in the Rule (stone, brick or terra-cotta), but in any case the cement used must be Portland (equal to the British Standard Specification of December, 1904), in the proportion of 6 cwt. of cement to each cubic yard of concrete. The Concrete must be thoroughly mixed both dry and wet, and must be rammed round the metalwork in position, every part of which must be completely enclosed with solid concrete.
>
> "No external wall to be less than 6 in. thick in any part, and no division wall less than 8 in. No party wall to be less than 13 in. thick in any part, unless the adjoining building be of reinforced concrete construction in accordance with Standard IA, IB, or II., in which case 8 in. is allowed.
>
> "Flues may be built of reinforced concrete as described, not less than 4 in. thick, if lined throughout with fire-clay tubes not less than 1½ in. thick. No timber or woodwork to be in contact with such flue.
>
> "Floors must be constructed of reinforced concrete as described, not less than 5 in. thick in any part without woodwork embedded therein, supported on beams and columns of similar reinforced concrete.
>
> "Roofs must be constructed in a similar manner to floors, the concrete in no part to be less than 3 in. thick.
>
> "All structural metalwork must be embedded in solid concrete, so that no part of any rod or bar shall be nearer the face of the concrete than double its diameter; such thickness of concrete must be in no case less than 1 in., but need not be more than 2 in.
>
> "Enclosure to staircase and hoist, if of reinforced concrete as described, may be 6 in. in thickness.
>
> "Fireproof compartments in connection with reinforced concrete structures must also be of reinforced concrete as described with walls not less than 8 in., and floors not less than 5 in. in thickness."

HYGIENIC PROPERTIES.

To comply with the spirit of the Home Office requirements a constructional material for factory buildings should be such as will not absorb dust or dirt in any form, which can be cleaned or kept clean with little effort, and which offers a fairly even surface. The other types of factory construction are mainly of brick walls and wood and steel-joist floors, and steel or iron columns, either cased or unprotected. It cannot be said that reinforced concrete offers any extraordinary advantages over the materials named. It is certainly better than brickwork; and in order to comply with the Home Office requirements it is more economical to lime-white than to paint, so that it may be considered to have an advantage over metal construction; and it is undoubtedly more advantageous to have large floor spans of concrete without subsidiary beams to obtain unbroken surfaces which can be kept scrupulously clean and white and, incidentally, which reflect daylight or artificial illumination in a most efficient manner. Therefore, on the whole, from a hygienic standpoint reinforced concrete has in the aggregate qualities which no other material possesses in an equal degree.

SAVING IN SPACE.

A further consideration which applies mainly to warehouse buildings is the importance of affording the utmost floor space for the storage of goods. Construction in London is exceedingly onerous in this respect. Matters have been made considerably easier by the steel-frame amendment of the London Building Act, but it cannot be denied that a considerable encroachment on floor space can be avoided by the use of reinforced concrete walls and supports.

The objection to reinforced concrete, as compared with steel and cast iron, in respect to posts and columns is that the floor space occupied is considerably more. This is undoubtedly the case, but, excepting in extreme circumstances, such as cotton or spinning mills, etc., the bulk of the concrete support is not a serious objection.

It should be remembered that if a steel stanchion is insulated against fire, it would be practically as great in sectional area as the concrete column.

VIBRATION.

An important consideration in all factories where machinery is employed is the aggregate vibration, which is often very considerable. The nearest approach to such solidity is to construct factories of reinforced concrete, which, while being of monolithic construction and free from joints as ordinarily understood in building construction, is an effective absorber of vibration. With this in view the use of slender columns and comparatively narrow beams are to be deprecated.

ADAPTABILITY.

Perhaps the unique merit of reinforced concrete lies in its extraordinary adaptability. There is no other building material which can be put to such extraordinarily diverse uses without unwarrantable eccentricity or expense. The value of a material which can be used for practically any purpose which may arise in the construction of the wide variety of buildings comprised in industrial works need hardly be dilated upon. The practical economy of such a material is also evident. Provided there are no insurmountable difficulties in getting on to the site steel rods, timber, gravel, and cement, we have at hand constituents which are capable of being moulded into any shape and resisting any strain and fulfil purposes which collectively would require the use of a large number of different materials. In the ingredients of reinforced concrete there is nothing which cannot be readily obtained in the most remote locality of the kingdom. In places ten or more miles from the nearest station, concrete work always can compete in point of economy with any other permanent form of construction, and wherever eccentric designs are to be carried out, a plastic material will always hold its own with a material which has to be wrought into shape.

SPEED OF EXECUTION.

Following on the adaptability of reinforced concrete is the speed with which construction can go forward. If a contractor will lay down a well-considered and efficient plant, the rapidity with which a concrete job can go forward is remarkable. A larger number of workmen (mostly unskilled labour) can be usefully employed, and the building as a whole can be proceeded with uniformly and in a manner which simplifies supervision. Should it be found desirable in a steel or iron construction to make alteration, time is lost in waiting for the various revised members to be delivered. With reinforced concrete such deviations can readily be made.

Another point in favour of reinforced concrete against steel construction is that minute variations in stress can be met without unduly wasting material.

ARTISTIC DESIGN.

An objection which is often urged against concrete buildings, which does not apply to brickwork or the usual form of construction, is that it is by nature unsightly. If appearance is an object in a reinforced concrete building a very agreeable effect can be obtained by perfectly legitimate and economical means. Those interested in the possibilities of beauty in reinforced concrete will do well to read Professor Beresford Pite's paper published in the " Transactions of the Institute," Vol. III.

ALTERATIONS TO FINISHED BUILDINGS.

Another objection which may be held against reinforced concrete, especially for factory construction, is the great difficulty of making alterations which may be found necessary for various reasons such as an extension of business; but, assuming the building has to be altered owing to circumstances which could not have been foreseen, such extensions and alterations are not impossible. Even if the expense is abnormal, it is one of those factors which every shrewd business man will be prepared for.

In this connection the American will frequently tell you that if he builds a factory which will last without undue maintenance a couple of generations, he has more than done his duty by posterity. We, personally, can hardly appreciate this point of view, but that the American is certainly willing to raze to the ground any building which he considers is out of date is evidenced by the fact that one of the New York skyscrapers is being taken down because after a few years' existence it is found to be inconvenient.

It cannot be denied that concrete, when it has settled down, is an exceedingly tough material, but the great strength to which this material attains should hardly be urged as an objection to its use.

STRENGTH OF REINFORCED CONCRETE.

The inherent strength of a building constructed entirely of reinforced concrete compares favourably with a building in any other material or combination of materials. Much has been said about the monolithic nature of reinforced concrete. We should not, however, forget that although a building is monolithic it is not monoferric (if such a word be allowable)—that is to say, that the steelwork consists of a multitude of small members held together by the concrete, but the external adhesion of concrete to steelwork makes a well-designed structure in practice a jointless one. Thus, an eccentric load on one portion of the building is disseminated over a large area of the surrounding structural members, and the local tendency of a building to spread or settle is resisted, not by the members locally affected but by the structure as a whole. In addition we have only to find the strength required in any portion and we can build up our structure to meet the stresses induced, where such stresses occur, and without wasteful extravagance such as is often necessary in compromising with steel construction in certain peculiar conditions.

BUILDING BY-LAWS.

An objection to reinforced concrete construction, which will die out in course of time, is the antipathy to a novel method of construction which is characteristic of the Englishman. I find, however, that individual building owners are easily converted if one honestly points out to them the limitations and the advantages of concrete. The most formidable objection lies in the present attitude of the official world, who, in spite of the splendid example which has been set by H.M. Office of Works in developing the use of this material in permanent and often monumental public buildings, have not been affected thereby to the extent of amending their by-laws. We have at present an eminently suitable material for the construction of permanent buildings with which it is difficult to satisfy local authorities who, on the other hand, will readily sanction a construction of light steel stanchions and roof trusses covered with corrugated sheeting. Fortunately, there appears to be nothing in local building by-laws which empowers the local surveyor to reject buildings in reinforced concrete, and if an architect can persuade his client to go forward wth his building I do not believe that he can be prevented.

DAMP RESISTANCE.

A minor advantage of reinforced concrete buildings is that no damp-proof course is needed, and when one realises that 50 per cent. of the damp-proof courses which are used with the approval of local authorities are worse than useless this advantage is one which, though unimportant, is nevertheless real.

A further minor advantage over steel construction is the obviating of nuisances caused in certain processes by condensation. Often condensation is unavoidable, and the results of same are often dangerous, harmful to the manufactures, or objectionable in other respects. With reinforced concrete condensation is reduced to a minimum.

BUILT-UP WORK.

In many cases it is found convenient or desirable to construct the building of units in a similar manner to ordinary steel construction, and this can be satisfactorily accomplished in reinforced concrete. The chief advantage of this is that a great deal of centring and strutting is saved, and the work can be handed over in a much shorter space of time than if the concrete had to set in the usual way. At the same time, it must be admitted that this form of construction is in principle open to objection, the monolithic nature of the buildings is destroyed, and it is certainly not so economical as casting the work in the ordinary manner. Its use is chiefly confined to floor slabs and walls, where it often offers very considerable advantages and economy.

FIXING PLANT.

The one great advantage of structural steel in factory construction is the ease with which machinery can be fixed to the steel members. That this use is often turned into abuse is beside the point, but engineers state that they prefer steel to reinforced concrete for this reason. A little foresight will enable an architect to meet this objection with satisfaction to the factory owner.

The bulk of a concrete member is so comparatively large in relation to a rolled steel member of equivalent strength, that the resulting damage of cutting into such member is proportionately reduced. Comparing the members, the sectional areas of the steel joist and of the concrete beam are in the proportion of 1 to 7 for equivalent strengths. Therefore the concrete member will stand much more mutilation without jeopardising its strength than the steel joist.

A simple means of providing for light fixings is obtained by casting a groove in the beams and columns so that a fixing can be obtained with the greatest ease without in any way having to go into the concrete. For gas or water pipes and mains or cables of any description, this fixing is very simple, and a good engineering job; again, the indiscriminate fixing of shafting to walls is accompanied with greater safety on reinforced concrete slabs than on brickwork, which is liable to give along the joints, and the weight, of course, is not so evenly distributed.

ROOF CONSTRUCTION.

The low thermal conductivity of concrete gives it an advantage over the ordinary forms of roofing, apart from other considerations. The usual precautions taken are to construct a roof of timber with thick boarding overlaid with felt, upon which are placed battens and counter-battens and thick slating. This forms a fairly effective insulation, but the construction is at least as expensive as a concrete flat asphalted. For flat roofs and in all places where exposed to damp or water pressure concrete can be made, with due care, absolutely waterproof, and a very valuable and convenient arrangement which is now often adopted is to construct concrete roofs with high parapet walls and utilise them for water storage. This has a further advantage that the water is generally at a convenient height to be drawn off under pressure.

VARIOUS APPLICATIONS OF REINFORCED CONCRETE TO FACTORY CONSTRUCTION.

ENGINE FOUNDATIONS.

Engine foundations are often exceedingly complicated, and for this reason it is impossible to construct them with plain concrete, so that it is common and often necessary to employ steel joists in order to avoid an excessive amount of concrete. It is obviously better to use a regular system of reinforcement wherever feasible. It enables the mass of concrete to be reduced to a minimum, and where, as is most frequently the case, the engine is to be set and a large proportion of concrete deposited after an interval, it is a great advantage to have some means of binding the mass of concrete together.

BOILER FOUNDATIONS.

With regard to setting the boilers, practically the only efficient manner for the Lancashire type of boiler, which is perhaps most common in this country, and also for the water-tube boilers of ordinary type, is to construct a concrete raft so as to offer a clear working space for the boiler-setters, and for this purpose reinforced concrete construction is the best possible. Raft foundations are constructed as floor slabs supported on piles owing to the uncertain nature of the subsoil. It is particularly recommended that piles for this purpose should be constructed of reinforced concrete, as it has frequently been found that where wooden piles are used the heat generated in certain portions of the flues is so great as to actually char away the head of the wooden pile and so cause settlement. The effect of heat on concrete is likely to cause failure unless a considerable period has been allowed to lapse after the construction before the heat is applied. In cases where a new boiler is installed and put into use immediately the setting is completed serious damage may be done to the concrete owing to the fact that it has not been allowed to dry off naturally. This damage would, of course, accrue to plain as well as to reinforced concrete, and in the case of the former, where the practice is often to make the concrete slabs several feet in thickness, the resulting damage (where the subsoil is good) is not appreciable; but in case of reinforced concrete, the slabs being thin, they may be entirely disintegrated.

BOILER SHAFTS.

It is only of recent years that chimney shafts have been constructed with true economy and efficiency in reinforced concrete, and all interested in this subject should read a paper delivered before the Institute by Mr. Matthews and published in the "Transactions," Vol. II., Part 1. This session a further paper is announced dealing with steel and reinforced concrete chimneys. Experience has recently shown the comparative cost of reinforced concrete chimneys, which, in one particular instance, showed a saving of 35 per cent. over a brick construction and a saving of 4 per cent. over steel-plate construction.

An objection to concrete chimneys is the unsightly appearance, chiefly owing to the fact that it is unduly expensive to form a side taper, but this difficulty has been overcome in a simple and ingenious way in some instances, and the system employed, so far from adding to the cost, is decidedly economical. In the cases in mind, the base of the chimney is quatrefoil in shape on plan, and the whole chimney constructed with one band of centring about 3 ft. high, which is raised, a batten taken out from each loop, and the centring correspondingly reduced in perimeter until it emerges into a circle at the summit of the shaft. The actual appearance is distinctly pleasing, and the insulation is good between the firebrick and the concrete. A certain amount of play is possible in expansion and contraction owing to the peculiar shape of the shaft, which is in effect equivalent to an expansion pipe on steam tubing.

SILOS AND BUNKERS.

The construction of silos and bunkers, which have hitherto consisted of iron or steel, has been found in the last few years to be considerably cheaper and equally efficient in reinforced concrete, and some most important works have been constructed in this material. The grain silos which have been constructed in various parts of the world afford a few typical examples. It is useless to press the claims of reinforced concrete in this connection, as so much work has been done in this country that it may be said that steel or iron construction is now out of date.

FOUNDATIONS.

Many serious difficulties connected with foundations on bad subsoils have been economically overcome by a discreet use of reinforced concrete. It is a fact that a large percentage of our factories are situated by rivers, canals, etc., and for this reason the foundations are generally expensive. This expenditure on foundations frequently results in land otherwise cheap proving in the end to be very expensive, as all such expenditure should properly be added to the cost of building land.

There is practically no form of foundation which cannot be efficiently constructed in reinforced concrete. A common, efficient, and economical form is the formation of a raft on which concentrated and distributed loads of a building are equally spread, so that the unit load is reduced everywhere within the limits of the bearing capacity of the soil.

Piles and sheet piles in reinforced concrete have been used in thousands, and its use in retaining walls has been able to offer the most extraordinary economies.

BRIDGES.

It is frequently found to be a great convenience to connect various departments above ground by means of gangway bridges, and as they are nearly always inaccessible, it is generally better to construct these of material for which maintenance is reduced to a minimum. Bridges are useful to cross public footways, and concrete has an advantage over brickwork or stone construction in obviating an excessive rise, and also in the saving of massive abutments.

CONCLUSION.

In conclusion, factory buildings are liable to be grossly overloaded, the costs are always reduced to the utmost farthing, and the buildings are not usually treated with such care as domestic or public buildings, and are liable to be severely mutilated and subjected to the deleterious effects of steam, vapours, fumes, acids, oils, and undue vibration, etc.; and, consequently, the factor of safety in design should never be reduced below four. It is also advisable to construct certain portions with even an increased factor, as, for instance, flat roofs which will with certainty be used for storage, and walls, beams, slabs, and columns, which are generally subjected to the suspension of shafting, motors, and other live loads without consideration of the purpose for which they have been actually designed.

In view of the enormous extent in which reinforced concrete has been used for buildings of this class during the past few years, it has been comparatively immune from failure.

DISCUSSION.

Mr. H. C. Johnson, of the Engineering Department of University College, Cork, forwarded a communication on the Paper, which was read, in the course of which he stated that it was worth while to visit America in order properly to understand why the Americans were able to build in reinforced concrete more cheaply than could be done on this side of the Atlantic. The reason that they were able to turn out more work per man was mainly due to new, well-lighted buildings, the great proportion of which were in reinforced concrete. It was possible in reinforced concrete construction to obtain a glass area equal to 80 per cent. of the total area of the building front, and run the glass to within three or four inches of the ceiling line. A large contract had been given to a reinforced concrete firm on their being able to prove that, including 12 years' maintenance, a concrete structure by them would cost less than if built in steelwork, the concrete first cost being higher. A saving of 15 per cent. on form work meant 5 per cent. more profit or less cost on the buildings. Another advantage of using reinforced concrete for buildings was that the greater part of the materials could be obtained locally, thereby keeping the money in the district.

Mr. Leslie H. Allen (Aberthaw Construction Co., Boston, Massachusetts, U.S.A.), also wrote that concrete was the only structural material which was made on the site of the buildings, and therefore there was a need of much more careful inspection of the work, and that the work itself should only be entrusted to those who had a thorough experience in the execution of it. Money was wasted or saved in reinforced concrete in the form work or centering, and everything that could be done to simplify that was of great advantage. The reduction of vibration was one of the points which appealed to owners of buildings having high-speed machinery or having a rocking or reciprocating motion, which was distracting to the people in the building and caused a rapid deterioration of the structure and the machines. Although there had been several failures in the last two or three years in America, not one of them had been after the building had been completed and taken over. They had all occurred in the course of construction, and they had been due to poor sand, faulty designing, or freezing the concrete before it set, overlapping green concrete, or removing the forms too soon, all these being the results of inexperience rather than any inherent defect in the material.

Mr. W. G. Perkins (District Surveyor for Holborn) thought it would have been more economical to have erected factory buildings to a height of three storeys. If brickwork were properly executed in Portland cement and solidly bedded up to the steel there was no danger of the steel rusting. That was the method prescribed by the Building Act, 1899. If it were not for the fact that the cement did protect the steel they should not be able to use reinforced concrete in their works to-day. Mr. Fraser, rather unfortunately, seemed to recommend that people should set by-laws aside, and put up reinforced concrete buildings whether the Local Authority liked it or not; but if they did not make their buildings in conformity with by-laws the Local Authority might proceed against them, and perhaps they might have an Order made for the demolition of the buildings after they were put up.

Mr. Allan Graham, A.R.I.B.A., remarked that anyone looking at the average type of work that was erected in reinforced concrete was quite satisfied with the lines, but the features that they placed into the work, and the lack of artistic grace precluded it from an architect's point of view entirely. They must try and interest the architects in reinforced concrete work in order that they might attempt to give a little artistic effect to the designs. Some of the American buildings, in South America especially, seemed to him to be much better designed. In centering he saw the only future to enable them to reduce the cost of reinforced concrete sufficiently that almost every factory in the country could be built of it.

Mr. Ole Svendsen, M.Soc.Danish C.E., did not see why a well-built brick chimney should be better than a well-built concrete chimney. With regard to maintenance, he believed that concrete chimneys would easily be able to compete with brick chimneys.

Mr. R. Graham Keevill, A.M.I.Mech.E., regretted that it was the cheapest building that was frequently put up. According to Mr. Fraser's paper, reinforced concrete had come out very favourably. The design of buildings was largely in the hands of specialist firms who were not at liberty to let the cost be known. If the cost of buildings were more generally known, that would be a large factor in helping forward the construction of concrete buildings, not only for factories, but for other purposes.

Mrs. Margaret Williamson Morris, who had had very nearly 30 years' experience of workshops and factories, appealed to architects for their assistance in combating dirt and darkness, and the want of air and light in such buildings as these, which contributed very largely to the spread of consumption amongst the working people.

The President referred to the increase of strength in concrete spread over, say, ten years. A lot of experiments were being conducted as to the strengths of different cements with all degrees of grinding, and there was no doubt that with coarse grinding it took very much longer to obtain its ultimate strength than with the finely ground. It was very much better to construct a factory of entirely reinforced concrete in the country, as architectural features, as a rule, were not studied to such an extent as they were in towns. In towns it would be a mistake, owing to the enormous amount of smoke, and the dirty appearance that it got, and the fact that the surface was always being attacked by the sulphuric anhydride in the atmosphere, which gradually caused it to crumble away. From the fire-resisting point of view, even if concrete cost more, the saving in premiums and insurance was very considerable. Vibration was very little felt in a reinforced concrete structure where it had been properly designed. In conclusion, the President referred to several serious cases of electrolysis which had occurred in the driving of piles in the East End of London.

MR. PERCIVAL FRASER'S REPLY.

In reply, Mr. Fraser said that in America they had very many buildings in reinforced concrete, and although its use had been artificially stimulated by the fact that the local building authorities were not so "pig-headed" as they were in this country, they could show more work and better work in this country than he had seen at all events in the United States. He reiterated his opinion that factory buildings, generally speaking, were cheaper when constructed in one storey than with two or more storeys. His statement was founded on very many years' experience of factory construction, and although he had been attacked from all quarters in regard to it, he had heard no constructive criticisms, merely statements that he was wrong. He was careful in his paper not to mention district surveyors. In his opinion they were a most excellent body of men. It was the provincial local authorities that put the extinguisher on a scheme because it was outside the by-laws. Those were the people they should defy. He agreed that brick panels were better than concrete panels for walls, for reasons of economy and because concrete slabs cracked. As to the cost of steel work, he was not aware that the prices on which he based his calculations were so wild. He denied that no building had ever been known to fall through rust, and instanced the case of Charing Cross Railway station. In his short experience of chimneys, he had replaced two steel chimneys with reinforced concrete chimneys, and both had lasted 12 or 13 years. Alluding to the remarks of Mrs. Morris, he said they had in reinforced concrete a particularly suitable material, its inherent qualities, and the manner in which it could be put together, affording large window space. The steam trouble had beaten better men than he, and no satisfactory system had yet been evolved to deal with it.

NEW WORKS IN CONCRETE

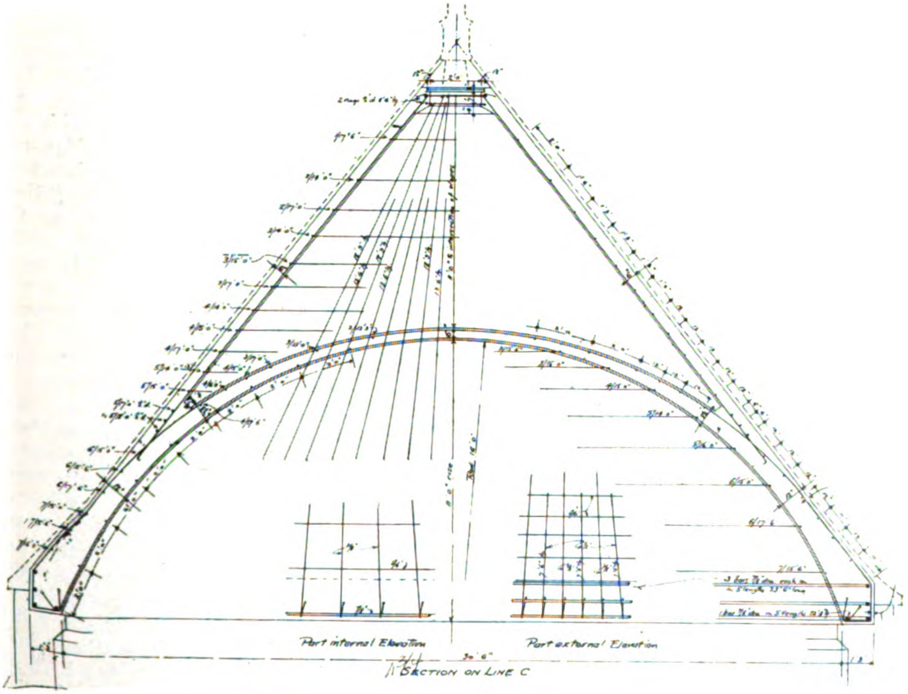
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

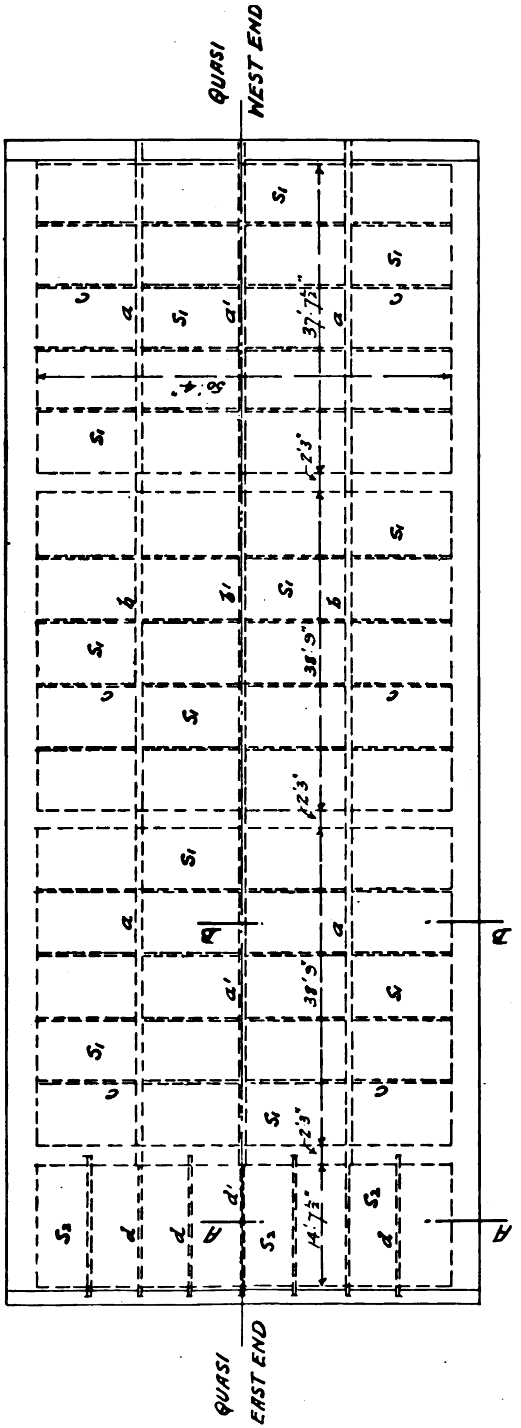
REINFORCED CONCRETE ROOF CONSTRUCTION AT LIVERPOOL CATHEDRAL.

ALTHOUGH reinforced concrete did not enter largely into the construction of this building, some interesting work is to be noted in connection with the roof construction. This work comprises the chapter house and choir roofs and some flat roofs over the small towers.

These latter are octagonal on plan and are finished by stone turrets in the form of pyramids, which are carried by the reinforced roofing. The clear width of the towers is about 11 ft. 3 in., and each is spanned by four beams, running in pairs at right angles, and interlacing one another about 15 in. from the wall face. Small beams having similar dimensions are carried diagonally across the corners of the square thus formed. These beams carry the stone turrets, and the enclosed octagon is left open.



Section Reinforced Concrete Chapter House Roof.
LIVERPOOL CATHEDRAL.

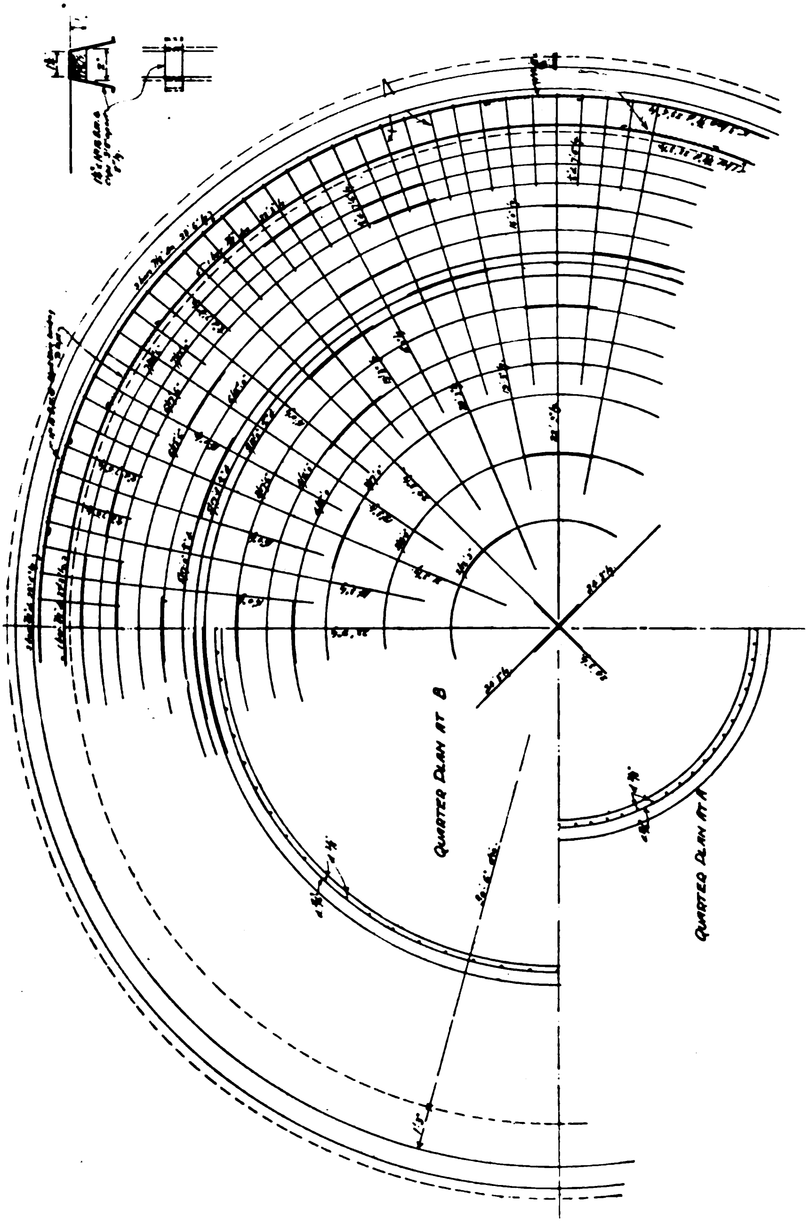


General Plan of Reinforced Concrete Roof.
LIVERPOOL CATHEDRAL.

The roof over the choir has a clear span of 50 ft. 4 in., with a somewhat shallow pitch, the inclination from the horizontal being 26 deg. The total length is 136 ft. 6 in., and the whole forms an external roof above the choir vaulting. The system of construction adopted is similar, on a larger scale, to that usually employed in ordinary timber roofs. The roof space is divided longitudinally into three compartments by transverse walls 2 ft. 3 in. thick, each compartment having a clear length of about 38 ft. At the east end there is a smaller compartment 14 ft. 7½ in. in the clear. The transverse walls take the place of principals, and the intermediate spans are bridged by ridge and purlin beams. These carry the smaller rafter beams, which have a span of about 14 ft., are spaced 8 ft. apart, and in turn support the general roof slab. The whole forms in reality an ordinary beam floor construction, arranged in two inclined planes. The ridge and purlin beams were designed as continuous over three spans, their depth being 3 ft. 3 in. at the supports and 2 ft. 3 in. at the centre of the spans. The small bay at the east end is constructed with a single system of purlin beams spaced 7 ft. apart. The ends of all the main reinforcing bars are hooked over to ensure a good anchorage, and the web tension bars are carried completely around the main reinforcements and turned down into the centre of the beam at the top. Where no top metal is required for compressional strength, constructional bars ½ in. in diameter are provided. The centring to the underside was wrought, and the surface will be left without any further finish. The external surface has been prepared to receive copper sheeting, hardwood slips being built into the slopes to provide fixing.

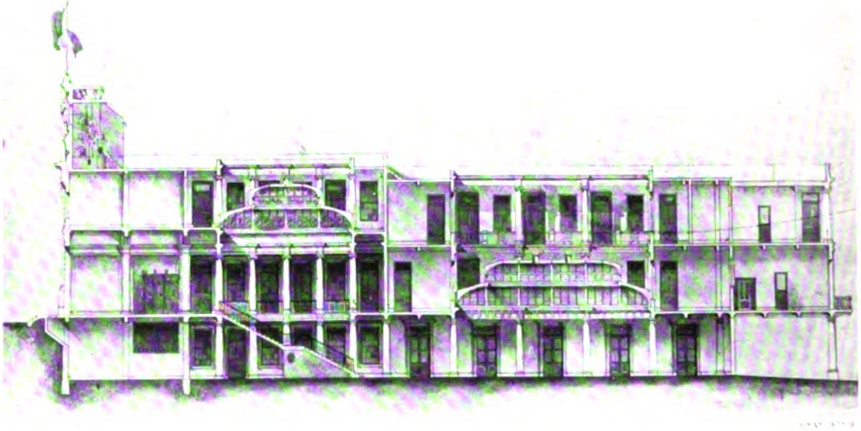
The most interesting roof is that which covers the circular chapter house. This building has a clear diameter of 31 ft. at the roof springing, and the walls are 1 ft. 9 in. thick.

An internal stone gallery encircles it just below the roof, supported by arches springing from the walls beneath. Although of ample strength to withstand the thrust thus put upon them, it was considered best that the walls should be relieved of all possible chance of additional thrust from the roof above. The internal dome has a

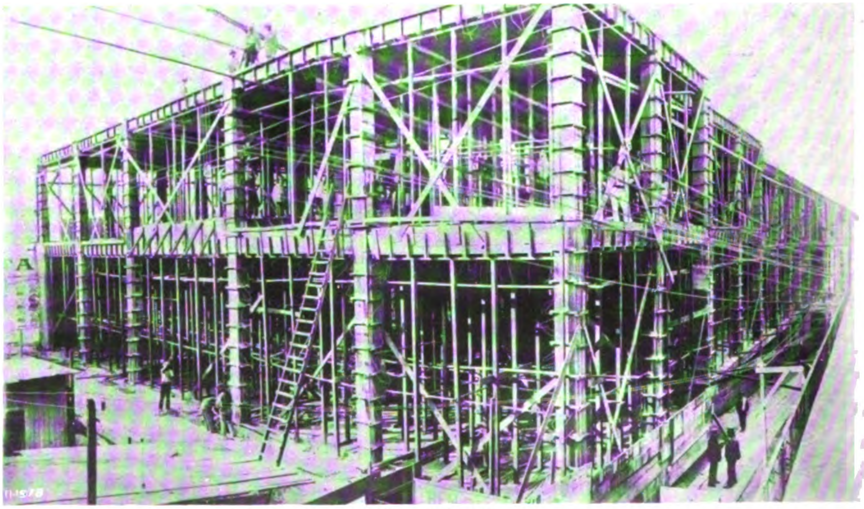


Part Plan of Dome (top).
Liverpool Cathedral.

radius of 16 ft. and rises 11 ft. above the springing, being 30 ft. 6 in. in diameter at that level. The height externally from the springing to the apex of the cone is 22 ft. 6 in. To provide against the possibility of thrust, the roof is encircled at the base with four series of ⅞-in. diameter bars, each in five lengths, for convenience in handling, with lapped joints of sufficient length to develop the full strength of the bar. For extra security the ends are hooked and the laps securely wired together for their whole length. The whole roof is thus transformed into so much dead weight to assist the walls below. The vertical hardwood slips bedded in the external slopes are in this case provided with hoop-iron anchor slips for greater security. This roof will be finished with copper.



Longitudinal Section.

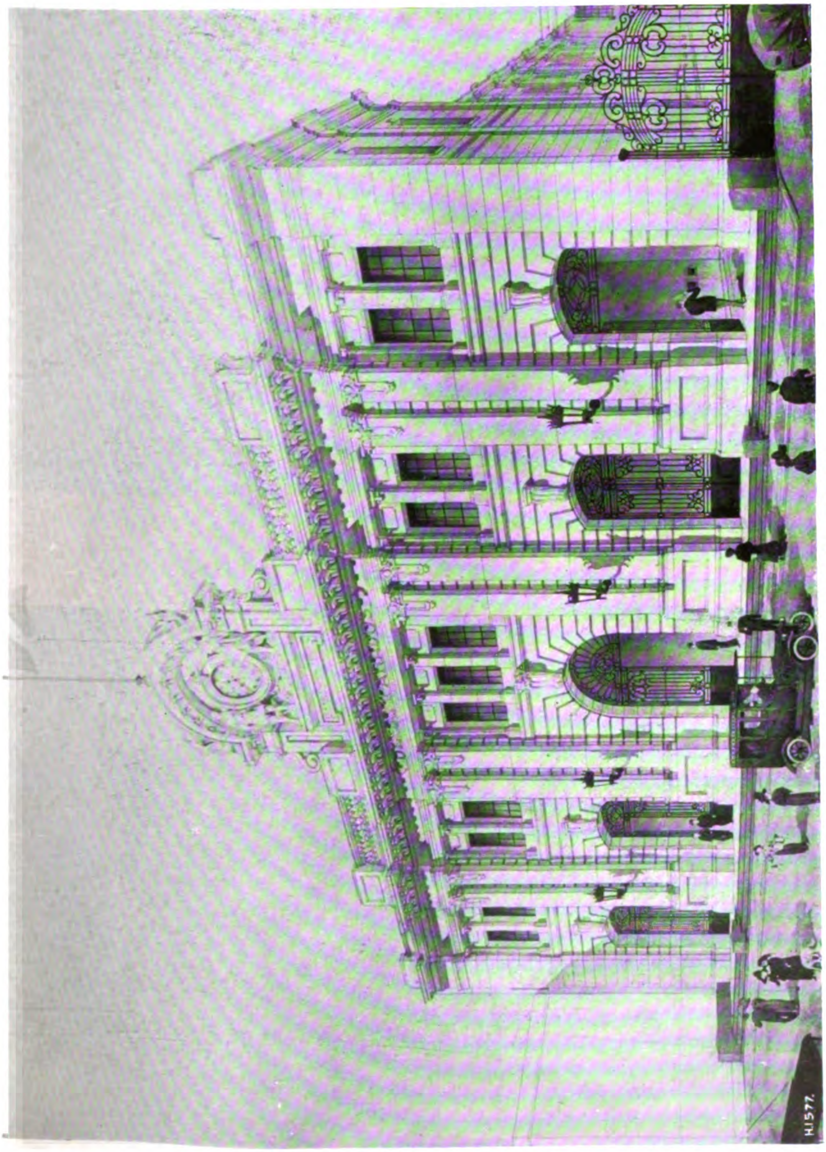


View of Building during Construction.
Desamparados Station, Lima, Peru.

In conclusion we would add that we are indebted to Mr. G. Gilbert Scott, the architect of the building, for our particulars and the drawings which he kindly placed at our disposal.

REINFORCED CONCRETE AT THE NEW DESAMPARADOS STATION, LIMA, PERU.

The building here described covers approximately an area of 2,150 sq. m., and consists of the station proper, on the ground floor, and the offices of the railway staff, on the two upper floors.



Front View of Finished Building.
Desamparados Station, Lima, Peru.

The structure is mainly of reinforced concrete. There are 92 reinforced concrete columns running through the three stories. The floors and roofs also are composed of reinforced concrete girders and slabs. All partitions are of hollow bricks, whilst the front of the building is faced with pressed blocks of cement and sand to imitate sand stone.

Concrete Block Crusher Station, Prestea, West Africa.

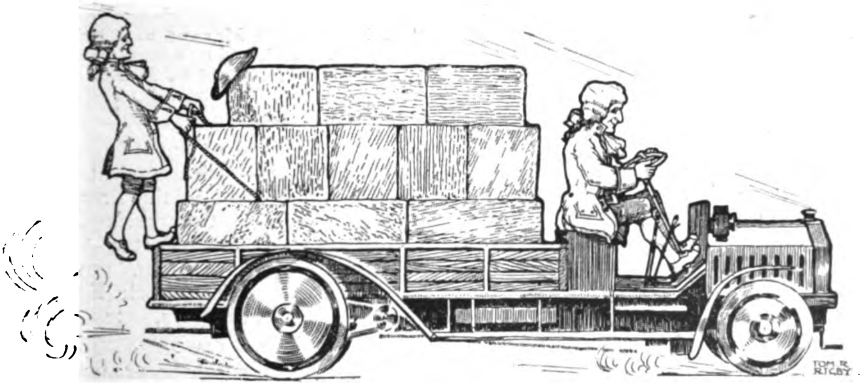
Concrete Block Loading Station, Prestea, West Africa.

A good idea of the building will be obtained from the accompanying illustrations. The whole of the work was carried out in 10 months. The architect was Mr. Rafael E. Marquina, whilst the reinforced concrete work was designed by Mr. M. M. Palo. We are indebted to one of our correspondents, Mr. O. L. Aliaga, for our photographs and particulars.

CONCRETE BLOCKS IN WEST AFRICA.

An interesting application of the use of concrete blocks for mine work will be seen from the illustrations on page 208, showing some work carried out on the Gold Coast. The illustrations show a new Loading Station and a new Crusher Station at the Prestea Gold Mines (Block A). "Winget" blocks were used throughout for this work.

The contractors for the work were Messrs. Thompson, Moir & Galloway, of Tarquah and Prestea, Gold Coast, West Africa.



NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Reinforced Concrete Construction." Vol. II. By George A. Hool, S.B.

The Hill Publishing Co., Ltd., 6 and 8 Bouverie St., Fleet St., London, E.C. 666 pp. + viii

Contents.—Retaining Walls—Theory of Stability — Design — Construction — Buildings—Design—Floors—Types of Reinforcement — Roofs — Columns—Foundations—Walls and Partitions—Stairs—Elevator Shafts—Contraction and Expansion—Continuous Beams—Eccentric-load Considerations in Columns—Wind Stresses—Design of a Factory Building—Example of a Building Design, including the Specifications — Construction — Materials —Forms—Bending and Placing of Reinforcement—Proportioning, Mixing, and Placing of Concrete—Finishing Concrete Surfaces—Waterproofing of Concrete—Construction Plant —Estimating Unit Costs—Estimating Quantities—Example of an Estimate for a Concrete Building.

This is the second volume on reinforced concrete by this author, and the first volume, which was reviewed in these columns in a previous issue, treats of the fundamental principles, and has been adopted as a text-book in a number of technical schools in America. The present book deals with the more advanced portions of the subject, and should be of service to engineers in practice, as well as to the advanced student. The diagrams throughout the book are excellent, and these have been prepared for the author by Mr. Frank C. Thiessen, with the exception of those pertaining to Construction Plant, the chapter on the latter having been prepared by Mr. A. W. Ransome. The chapters on Estimating have been written by Mr. Leslie H. Allen, and these form a useful portion of the book.

The theoretical parts of the subject are treated in a very thorough manner, and the author does not appear to consider any point too small or unimportant to be unworthy of explanation. This section is well arranged, and the various examples, which are completely worked out, are given in such a manner that the reader is able to follow the application of the theory and set his mind at rest on any point which does not appear quite clear at first sight. The practical portions are illustrated with numerous photographs of work actually executed or in course of construction, and these render this section of the volume very interesting.

The shear and moment considerations in continuous beams are dealt with very fully, and great pains are taken to instil the elementary principles into the mind of the reader before proceeding to the more complicated reasoning and formulæ. The English reader may experience a little difficulty owing to the fact that the notation is different to that generally employed in this country, but a study of the book will well repay the reader.

"A Manual for Masons and Bricklayers." By J. A. Van der Kloes. Revised and adapted by Alfred B. Searle.

London: J. & A. Churchill, 7 Great Marlborough Street, W. 235 pp. + xii. Price 8/6 net.

Contents.—Physical and Chemical Notes —Masonry—Bricks and Stones—Raw Materials used in the Preparation of Mortar—The Composition, Preparation, and Use of Mortars—The Composition, Preparation, and Use of Concrete—Other Work Executed by Masons, Plasterers, etc.—Estimates and Costs.

This volume has been prepared by Mr. Searle to put before English and American readers the researches of Professor Van der Kloes, who is the Professor in the Science of Materials of Construction in the University at Delft, and the particulars have been modified and adapted to render them more suitable to the readers in this country. Great stress is laid on the necessity of using suitable mortar in all kinds of constructional brick and stone work, and the physical and chemical notes which deal with the defects that commonly occur are interesting and certainly put the various items in a new manner which is clear and convincing.

Shrinkage and expansion, watertightness, weathering, wall cancer, and osmosis are among the points dealt with, and the whole chapter forms a good introduction to the book.

Generally speaking, the practical notes are not so good as those devoted to the theoretical aspect, and it is from the latter that the most valuable information can be obtained.

The notes on reinforced concrete are very meagre, and furthermore do not express the nature and functions of the component parts in a satisfactory manner, although the author states that the use of the material ensures a security against fire which is unobtainable in any other way. There are many points in this section of the work which will not be accepted by the majority of engineers, but they are of some value to the reader nevertheless. Various suggestions are given for the surface treatment of concrete, but the author is not of the opinion that a rich architectural treatment can be obtained without the use of brick or stone facing.

"Lockwood's Builders' and Contractors, Price Book for 1914."

This price book is for the use of architects and surveyors and those connected with the building trade. It has been brought carefully up to date, and due effect has been given to the rise in prices of materials and labour in the various trades.

The first part of the book deals with every kind of building work, and the prices and wages tables have been brought up to date and considerably enlarged. The section dealing with electric lighting has also been added to.

Much useful information is given in the appendices, in which are tables of weights, areas, etc., solicitors' costs, stamp duties, tables for the valuation of leases and estates, legal notes and memoranda, as well as judicial decisions and Parliamentary enactments.

There is also the form of Building Contract and Schedule of Conditions issued by the Royal Institute of British Architects, as well as a copy of the London Building Act and its amendments.

'Spon's Architects' and Builders' Pocket Price Book."

This well-known price book forms a valuable reference for all those in any way connected with the building trade.

The book has been brought thoroughly up to date, and a great many additions have been made in the various prices, so that the diary has had to be omitted to keep the book a reasonable size for pocket use.

The usual order of trades is adopted as in a well-drawn bill of quantities, and there is a fully-detailed index to the trades, so that any information which is required is quickly found.

"The Maintenance of Foreshores." By Ernest Latham, A.M.Inst.C.E., A.M Inst.M.E.

London: Crosby, Lockwood & Son, 1914. 84 pp. Price 2/- net.

This little book deals with a subject of great interest and importance, but in a very incomplete manner, being hardly more than a grouping of detached notes on certain aspects of the subject. Some of these notes are, however, highly suggestive. The Royal Commission on Coast Erosion has presented an extensive report (a short summary of which is given in this book), indicating the urgent necessity of protective works. Legal problems of a somewhat intricate character present themselves in this connection, and the author deals with these and with the closely related question of administrative authorities. On turning to the practical means of protection, however, the reader is disappointed, the treatment of this subject being rather scrappy and of less value than might be expected from an author of such experience in the execution of coast protection works.

It may be noted that groyning, as commonly carried out, is considered to do almost as much harm as good. Favourable reference is made to the Dutch system of protective aprons, and the suggestion is thrown out that such aprons might be improved by oblique steppings, at right angles to the prevailing set of the waves. No details of the method of construction of protective works are given, and there are no illustrations. Some notes on the preparation of concrete are included, but the account of reinforced concrete only extends to a page, most of which is occupied by tests of the steel reinforcement. Exception may be taken to the statement, referring to reinforced concrete sea walls, that the system to be adopted is the first consideration. The principles of construction of aprons, etc., are now sufficiently well understood for the competent engineer to design his reinforcement without slavish adherence to any patent system.

Colonel Crompton contributes a chapter on surfaces with bituminous binding for marine promenades.

"Experiments with Built-in Beams." (Versuche mit Eingespannten Balken.) By Dr. Fritz E. von Emperger.

Leipzig & Vienna: Franz Deuticke, 1913. 259 pp., 250 Illustrations and Plates. Price M. 10.

This memoir contains a full description of the experiments, an account of which has already been given in this journal. It may be regarded as forming a complete treatise on the theory and practice of the subject, and is very fully illustrated by diagrams and photographs. The principal conclusions drawn from the very extensive experiments on a large scale may be recapitulated here.

All reinforced beams which have been erected without special devices to ensure a free bearing must be regarded as wholly or partially fixed, and allowance must be made for the fixing moments. It follows that the compression zone in beams should never be entirely without reinforcement. With sufficiently good union of beam and bearing, the beam may be computed as completely fixed, in which case the abutment may be considered to include an element of the wall broader than the beam, to an extent depending on the quality of the masonry or concrete. It is best to make the reinforcement of beam and wall continuous, as in framed construction, but precautions must be taken against settling.

The book is handsomely produced.

"Technical Studies of Mortar and Cement." (Zement-und Mörteltechnische Studien I.) By Dr. Hans Kühl.

Berlin: Verlag der Tonindustrie-Zeitung, 1913. Price 5 Marks.

Dr. Kühl is the successor of the late Dr. W. Michaëlis, and his investigations into the chemistry and technology of cement have the same originality and interest as those of his distinguished predecessor. This little collection of memoirs and addresses deals with a variety of subjects, from the expansion of cement containing sulphates to the use of gas analysis as a means of controlling the fuel consumption in rotary kilns. Concerning the first point, the author produces evidence to show that it is not the absolute quantity of sulphates which determines expansion, but its ratio to the lime content. Thus with cements of hydraulic modulus 2·30 to 2·15 the best result is obtained with 3 per cent. of gypsum, whilst a cement low in lime, with hydraulic modulus 1·85, is strongest with 6 per cent. of gypsum, and in fact the true Portland character does not appear in such cements until the proportion of gypsum is considerable.

A new test for constancy of volume was proposed by the author in 1912, consisting in boiling tests with thin pats of the German form, but made with mixtures of cement with very finely ground normal sand. It is to be noted, however, that many cements would pass this test which fail in the Le Chatelier test. The use of fluates is recommended for the treatment of cement and concrete surfaces which are to be painted with oil paint.

"Silo Construction in Concrete and Reinforced Concrete." (Silobauten in Beton und Eisenbeton.)

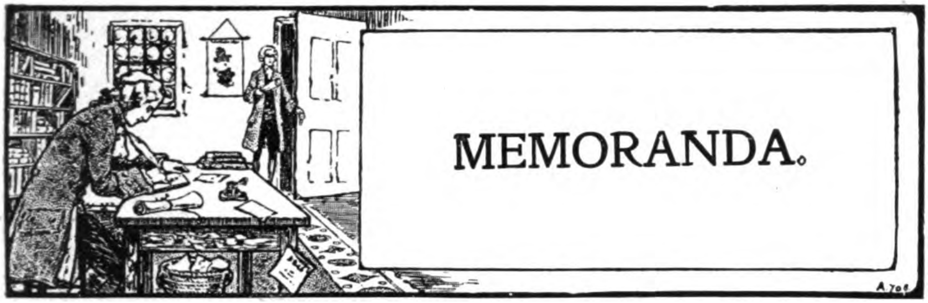
(Heft 4 of Cement-Verarbeitung.) Cement-Verlag G.m.b.H., Charlottenburg, 1913. Price Pf. 35.

A pamphlet detailing the advantages of concrete, especially reinforced, for the construction of silos. Descriptions, with many plans and photographs, are given of silos which have been erected to contain grain, coal, ores, cement, wood-shavings, etc. The methods of reinforcement and of statical computation are also described. Rectangular, cylindrical and hexagonal silos have been used, and the types of design and construction may be varied widely according to circumstances. It is evident that reinforced concrete is in every way superior to steel, wood or brickwork for structures of this kind, the number of which is increasing rapidly.

"Posts and Masts." (Pfosten und Maste.)

(Heft 3 of Cement-Verarbeitung.) Cement-Verlag G.m.b.H., Charlottenburg, 1913. Price Pf. 30.

Another of these useful little German monographs, describing the design and construction of reinforced concrete posts, telegraph poles, tramway and electric light standards, etc. The lightness of construction which is possible with this material is surprising, and some excellent examples of really graceful and artistic standards for lamps, tramways, etc., are reproduced. The high elasticity is shown by bending tests, the masts returning completely to their original form after a deflection amounting sometimes to as much as a metre at the free end. On account of the difficulty of construction, these long masts are usually made by special firms using patented processes.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Building By-Laws and Reinforced Concrete.— The Chiswick Urban District Council, under their Act of 1911, obtained powers to relax or modify their by-laws with respect to new streets and buildings as to buildings of iron, steel, or reinforced concrete, and have recently made the following regulations:—

(1) All future one-storey ferro-concrete structures be considered permanent buildings, provided that in the Council's opinion sufficient strength is allowed for in the construction of (*a*) supporting walls, and (*b*) all flat pitched or horizontal roofs.

(2) That ferro-concrete dwelling houses be considered permanent buildings, provided that all floors are calculated to carry a minimum load, including the weight of the floor, of one-and-a-half hundredweight per foot super, with proportionate strengths for supporting walls.

(3) That ferro-concrete factories, warehouses, and public buildings of more than one storey be not approved as permanent buildings, unless an undertaking by the owner is deposited with the plans, etc., stating that he will not permit or allow the agreed maximum safe loads as set forth upon all parts of such plans to be increased in any part thereof without the permission of the council being first obtained.

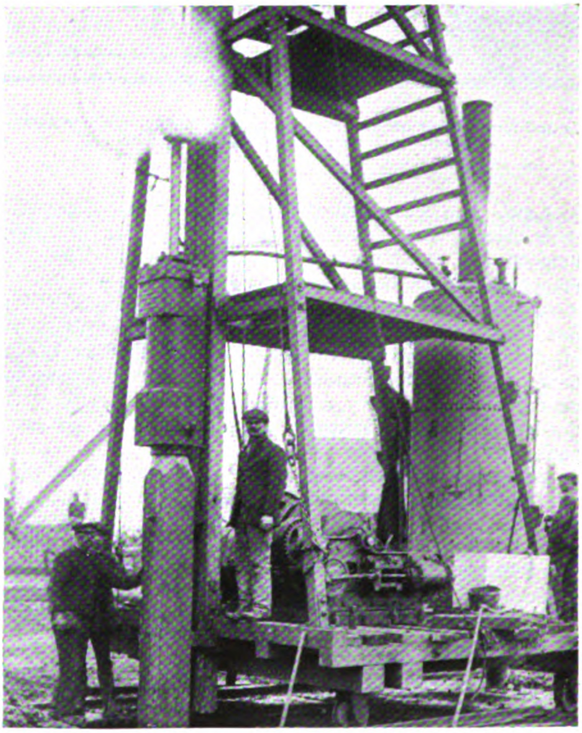
(4) That the recognised general engineering formulæ for beams supported at each end be utilised for all calculations except in the case of continuous beams over three or more spans, in which case the external spans must be treated as beams supported only.

(5) That fully detailed plans, sections, and elevations of all reinforced concrete buildings must be submitted with a detailed specification, and on such drawings must be shown the proposed maximum loads, together with the calculations upon which the strength of all walls, columns, floors, and roofs have been calculated.

Action of Sea Water on Concrete.—More than twenty concrete piers built several years ago by the Aberthaw Construction Co., and submerged in the United States Navy Yard at Boston, are again being examined to note the action, both mechanical, due to frost, and chemical, due to ingredients in the sea water. As this subject is one which has a large bearing on the permanence of piers, abutments, sea walls, etc., when built of concrete, these experimental tests are expected to yield some very valuable results.

Wire Ropeway Supports in Concrete and Reinforced Concrete.—Wire ropeway supports were originally only made of wood or iron. The wooden supports were bedded into the earth, or they were mounted in the same way as iron supports on masonry or concrete. The necessity arose occasionally of throwing hot ashes and slag from the carrying rope of supports on to a dump, and the supports were gradually buried in. Danger thus arose of large parts of the dump catching fire, and for this reason neither wooden nor iron supports were suitable. Means were resorted to to remove the pressure of the dump material from the supports. These were then built of bricks, or stamped concrete pillars were set up as raised foundations on which only short iron carrying heads were fixed. Supports of this kind were made by Messrs. Adolf Bleichert, of Leipzig, and our second illustration shows such supports erected some years ago for the sugar factory of Messrs. Dobrovitz, in Bohemia, by Messrs. Bleichert. Latterly

PILE DRIVING PLANT



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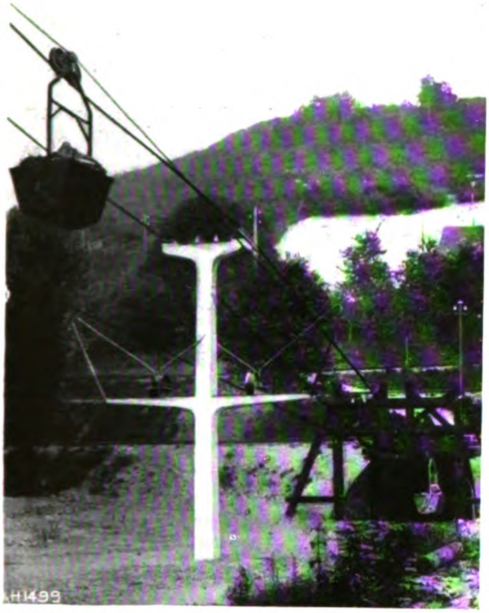
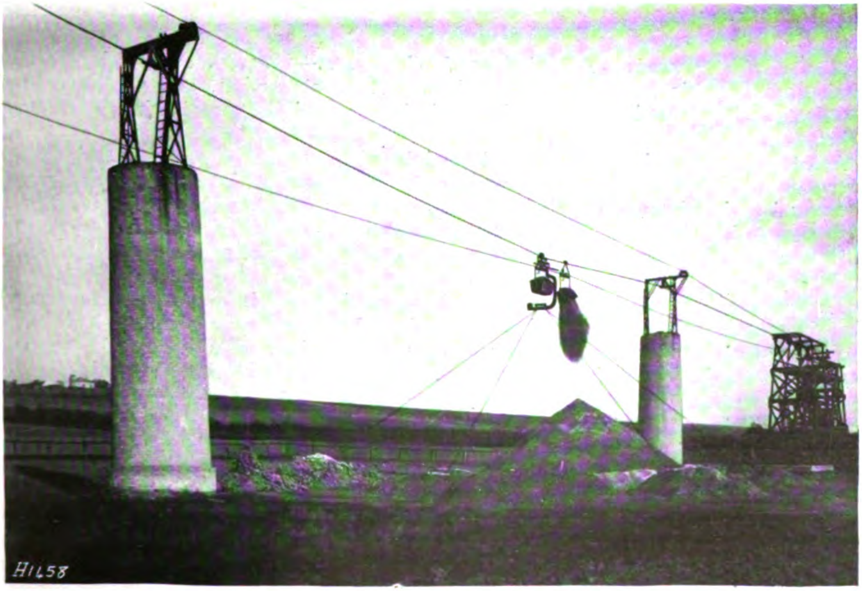


Wire Ropeway Supports in Reinforced Concrete.

actual reinforced concrete supports have been erected for cement factories which carry the ropes on cross-beams. These are seen in the first illustration, and were built for a cement works abroad, and were made by the same firm mentioned above.

Sieving with Standard Cement Sieves.—The Bureau of Standards, U.S.A., have recently issued a Paper (No. 29), by Messrs. R. J. Wig and J. C. Pearson, dealing with variations in results of sieving with standard cement sieves. We are unable to give the report in full, which deals with various experiments carried out, but we publish below the conclusions arrived at, as they may be of interest and prove useful to many of our readers:—

> In reviewing the results of the tests made the following conservative estimates may be given:
>
> 1. Employing the present standard method of sieving, the greatest attainable accuracy in single fineness determinations of normal Portland cement on a standard No. 200 sieve—that is, the greatest attainable accuracy in checking uniformity of samples—is about 0·2 per cent.
>
> 2. "Standard" No. 200 sieves may differ in their sieving values by considerable amounts, such that their corrections to the ideal No. 200 sieve may be at least as great as 0·7 per cent.



Concrete Wire Ropeway Supports.

3. Errors of at least 0·5 per cent. may be looked for in single fineness determinations of normal cements on a standard No. 200 sieve when made in the usual routine manner.

4. Deviations exist in the sieving values of "standard" No. 100 sieves, of a magnitude, roughly, one-half the corresponding values for No. 200 sieves as given above.

5. "Personal equation" appears to be appreciable in hand sieving, as in most laboratory operations, the observed values being as great as 0·3 per cent.

6. The rating of a sieve by some system of demerits assigned from direct measurements appears to be an interesting possibility, and worthy of further study. Should a system be worked out to give reliable indications, say within 0·2 per cent. or 0·3 per cent. of the observed sieving value of a sieve, it will add greatly to the value of the certificate now furnished with standard sieves.

It seems evident from the foregoing that both sieving tests and the interpretation of measurements on sieves are subject to considerable discrepancies, and the question arises as to whether some other more reliable method of determining fineness cannot be made available. The sieve at best is a measure of the *coarseness* of finely ground material rather than the *fineness*, and experiments now in progress at the Bureau of Standards indicate that air separation will offer a more satisfactory means of determining fineness than mechanical sieving.

In conclusion it may be stated that a tolerance of 1 per cent. from the specification should be allowed with the No. 200 sieve and 0·5 per cent. from the specification with the No. 100 sieve, every care being taken to conduct the test in strict accordance with standard methods. These tolerances should be considered as minimum values since they are based upon the results obtained by careful and experienced observers; therefore it should be emphasised that greater differences are possible in ordinary routine testing.

Concrete-Hardening Material.—A material for hardening concrete now being introduced in the United States contains 95 per cent. of iron dust, which is mixed with cement for finishing the surface of concrete floors. From 15 lb. to 25 lb. of the material is mixed with 100 lb. of the cement while dry, and one part of this mixture to two parts of sand makes the slurry for the top coat, which varies from 0·5 to 1 in. in thickness. It is said to make a hard and durable floor, which is waterproof and not slippery. The hardening material is used also to make new concrete adhere to old in repair work.

TRADE NOTICES, CATALOGUES, ETC.

The Kahn System of Reinforced Concrete.—Most of our readers are well acquainted with this form of reinforced concrete construction, and we have in this Journal given illustrated articles and descriptions of buildings and other work erected on this system.

A new catalogue has just been issued by the Trussed Concrete Steel Co., and every endeavour has been used to produce this publication in an attractive manner. The book is printed on the loose-leaf system, so as to enable sections of it to be sent out to people interested in the respective subjects illustrated.

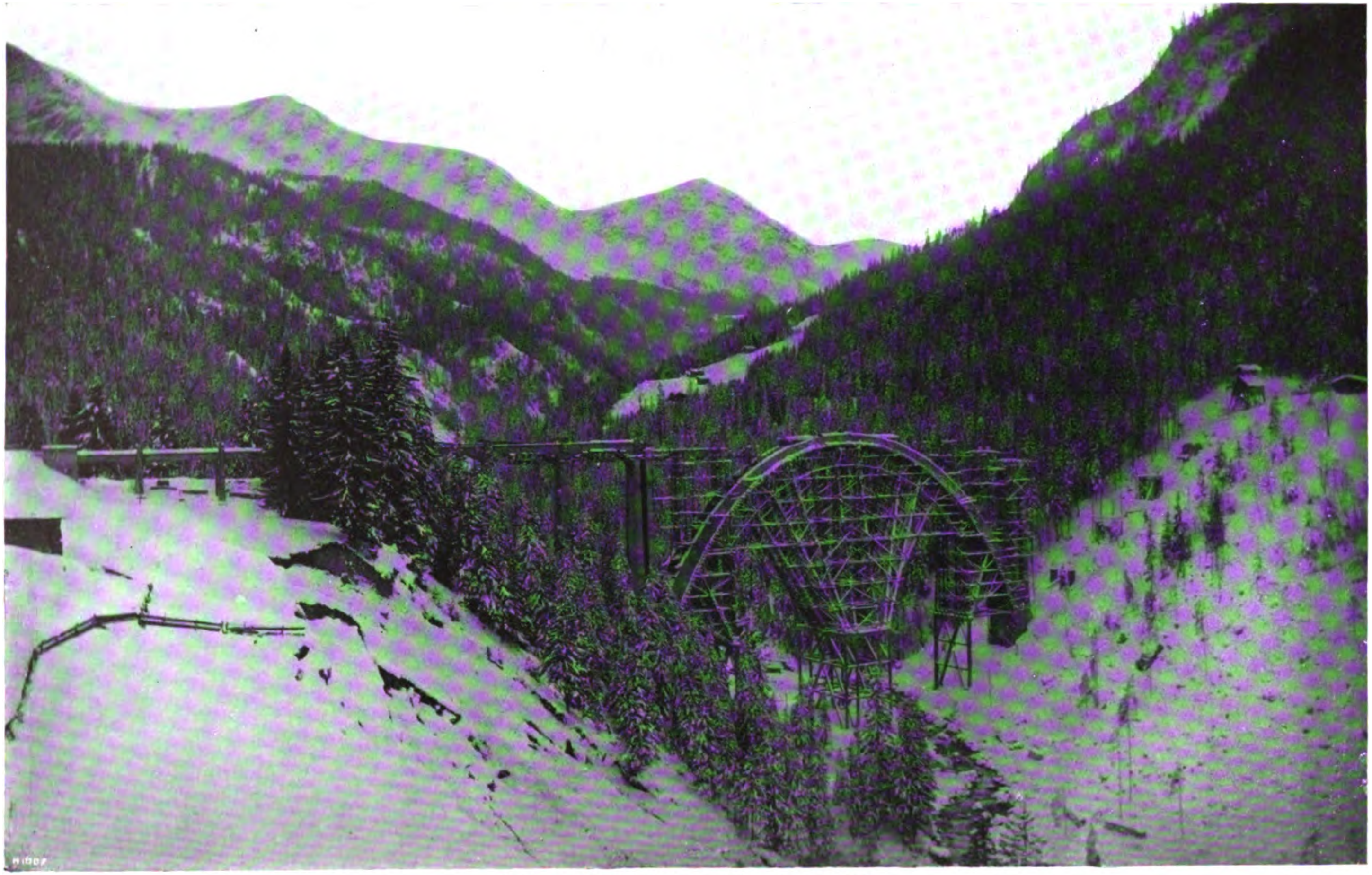
It contains numerous illustrations of important structures carried out on this system.

There are also some notes dealing with the subject of reinforced concrete generally, and a few pages are also devoted to describing the Kahn system in particular.

Those of our readers desiring for further information, or a copy of the catalogue, should apply to the Trussed Concrete Steel Co., of Caxton House, Westminster, S.W.

The Empire Stone Co., Ltd.—A new catalogue has just reached us from this company. This publication contains a number of interesting examples of buildings in which reinforced concrete has been employed. Not only are the various works illustrated, but in each case a short description is given of the reinforced concrete work carried out by the company.

The examples include factory construction, retaining walls, staircases, bridges, rafts, etc. Copies of the catalogue may be obtained on application to the company at Thanet House, 231, Strand, W.C., or at their offices in Birmingham: Winchester House, Victoria Square, Birmingham.



Bridge in Course of Construction, Dec. 9, 1913

Reinforced Concrete Viaduct at Langwies, Switzerland.

*(For Description see **p.** 250.)*

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume IX. No. 4. LONDON, APRIL, 1914.

EDITORIAL NOTES.

THE CONCRETE INSTITUTE.

The Present Unfortunate Effort to Change Its Objects and Title.

WE have from time to time referred to a tendency on the part of certain members of the Concrete Institute towards utilising the Institute for their particular purposes. These members have been very persistent in their endeavours. It has thus come about that although the general membership had not realised it at the time—and, as a matter of fact, many members of the Institute's Council had not realised it either—a change of Memorandum was adopted at an Extraordinary General Meeting last winter whereby the Institute, instead of remaining an institute intended for those concerned in works in which concrete and reinforced concrete play a part, is apparently to become an institution for those concerned in structural engineering.

Now we grant that there may be ample room for some institution concerned specifically in structural engineering, although our own experience is that the Institution of Civil Engineers and the several junior engineering societies have long afforded ample facilities in this direction, and we would naturally not raise any objection to such an institution being formed if there were a *bona fide* demand for its constitution. But for those concerned in structural engineering to change the entire objects of the Concrete Institute and subordinate concrete and reinforced concrete to structural engineering would be a mistake indeed. One has only to remember how unkindly reinforced concrete was for many years treated in the Institution of Civil Engineers to understand what its position would be in the Concrete Institute if the objects and title of that body were changed.

The Concrete Institute was primarily intended for the exchange of experience between *all* the various professions and industries concerned in concrete and reinforced concrete, which included Civil Engineers, Architects, Surveyors and Quantity Surveyors, Mathematicians, Scientists and Industrial and Cement Chemists, Manufacturers and Contractors, and last, but not least, the Concrete Specialist. The Concrete Institute, as it is now apparently the intention to re-model it, is, however, simply to become an institution of structural engineers, and thus the architect, the chemist, the scientist, and the mathematician is either ruled out altogether or is to play a very secondary *rôle* as an "Associate," or what not.

Application to the Courts.

Legislation, however, has fortunately provided that change in the Memorandum of an incorporated institution of this kind must have the sanction of the High Court, so that errors may be avoided and the interests of the members as a whole safeguarded.

From numerous letters we have received, it would appear that the Court is to be applied to in the near future, but several sections of the professional members, a group of those concerned in the concrete industry, and one or two other groups, appear to be organising opposition. On the other hand, some of the municipal surveyors appear to welcome the change, and the steel frame contractors and their assistants are jubilantly delighted.

Our View.

Our own view on the proposed change is obvious. We have assisted the Concrete Institute with advice and publicity as a corporation with a specific purpose. We consider an independent Concrete Institute a necessity and approve its original objects and constitution. It is our intention to use every possible legitimate endeavour that those objects be retained. We shall thus oppose to the best of our power any change that diverts the objects of the Concrete Institute from its primary purpose, and we shall certainly oppose any change from its very excellent and concise title.

Apart from the question of the Concrete Institute *per se,* we think it is a national question that this country should have a *bona fide* Concrete Institute and not lag behind other countries in this direction. The Empire requires some centre where all professions and vocations concerned can exchange opinions on the subject, and also some centre that can speak independently as representative of *all* the interests concerned in these important days of new developments in building—both domestic and utilitarian.

A Referendum of our Readers.

For this reason, we propose also sounding the general view of our many subscribers and readers as far as it is possible on the subject, and we are enclosing a postcard which we will thank the recipients to return (stamped or unstamped), but filled in in such a form as to give us some idea as to the general views of our supporters on this subject. It is equally important for us to know the views of our most junior readers in a far distant colony, as it is to know that of the great engineer who practises in Gt. George Street. It is equally important for us to know the views of individuals and of corporations, and we trust that the postcard will be replied to by a large number of our readers. In these days of "referenda" and polls, it is particularly useful for us to know what the feeling on the subject is, seeing that even the great majority of the members of the Concrete Institute have not had an opportunity of voicing their views on the subject, the attendance at meetings being naturally limited to a few London members.

We will welcome, apart from the reply to the postcard, correspondence on the subject. Our endeavour is to retain for the nation a Concrete Institute of standing that may have the same prestige in respect to concrete in the world as the prestige of the Iron and Steel Institute for steel, or the Institution of Naval Architects in the matter of ship construction. The reputation must not only be a national reputation, but an international reputation, and this tinkering at the Memorandum and Articles of the Concrete Institute is fatal to the standing of this body.

A Possible New Organisation.

We think it is only fair to announce that we have been approached from an entirely unexpected and very powerful source to form another institution solely in the interests of concrete and reinforced concrete, should the objects of the institute or its title really be changed with the sanction of the Court. We think that consideration of this matter is premature, as we have some doubt as to the Court sanctioning a change of Memorandum opposed by influential members and, may be, by other corporations and by the public. We have thus for the present declined even to consider the matter.

But the fact that some such idea has been mooted by distinguished men solely interested in scientific and experimental aspects of the subject and who are not connected with the Institute should make that body reconsider the advisability of the change of objects and title so ardently desired by some of its strenuous members, and also whether it is worth while to fritter time and funds on interminable strife—within and without—which waste of effort and money can result in nothing less than the institution's gradual collapse or supersession.

REINFORCED CONCRETE AND INTERNATIONAL INVESTIGATION.

WHILST at home some people seem to think that investigation relating to concrete and reinforced concrete is not a sufficiently wide field for a Concrete Institute, international and foreign bodies continue to set up new organisations to cope with different sections of inquiry, for which there is not only a demand among the professions concerned, but considerable popular interest.

Besides the well-known International Commission on Reinforced Concrete, formed at the instance of the International Testing Association, to which we have had occasion to refer from time to time, the Association in question has also taken the initiative in forming two further International Commissions that should have an important bearing on reinforced concrete.

Fire Resistance of Reinforced Concrete.

The first of these is an International Commission on the Fire Resistance of Concrete and Reinforced Concrete. Delegates have been nominated from all the principal countries in Europe and from the United States of America, and Mr. Edwin O. Sachs, F.R.S.Ed., Chairman of the British Fire Prevention Committee, has been elected President of the Commission. The British delegates, we should here add, are Mr. Ellis Marsland (district surveyor); Mr. W. Kirkcaldy, A.M.Inst.C.E., head of the well-known testing laboratory; and Mr. D. W. Wood, an insurance surveyor.

The American delegates are the following:—Professor Ira H. Woolson, National Board of Fire Underwriters, U.S.A.; Mr. Richard L. Humphrey, President American Concrete Institute; Professor Charles L. Norton, Massachusetts School of Technology; and Mr. R. P. Miller, Superintendent of Buildings, New York.

Whilst amongst other delegates we would specially like to name the following appointments:—From Germany: Professor Gary, of the Lichterfelde

Testing Station, and Chief Officer Westphalen, of the Hamburg Fire Brigade; from Austria: Professor Melan, of the Technical College, Prague, and Professor Saliger, of the Technical College, Vienna; whilst from Denmark the delegates include Chief Officer Liisberg, of the Copenhagen Fire Brigade.

Reinforced Concrete Accidents.

The other International Commission that has been formed is an International Commission on Reinforced Concrete Accidents, and of this Dr. von Emperger, of Vienna, has been elected President. The British delegates in this case are:—Mr. Edwin O. Sachs, F.R.S.Ed.; the Concrete Institute is represented by Mr. H. Kempton Dyson (Secretary) and Mr. S. Bylander. Australia has in this instance also three delegates, viz., Mr. J. J. Clark, architect (Melbourne); Professor W. H. Warren, Sydney University, and Professor Robert Scott, Canterbury College (Christchurch, N.Z.).

The delegates from the United States are:—Mr. Richard L. Humphrey; Professor A. N. Talbot, of Illinois University; and Professor F. E. Turneaure, of Wisconsin University.

Of other countries the following are distinguished members:—Denmark has, among her delegates, Professor E. Suenson, of the Copenhagen Technical School; France, Professor Mesnager, director of the Laboratory of Ponts et Chaussées, and Mons. Hennebique; Germany has Dr. W. Petry, of the German Concrete Institute; and Switzerland, Professor Schüle.

We here would specially point to the interesting feature that Japan has in this instance also appointed three delegates, viz., the following:—Professor Tadahiko, of the Imperial University, Kyoto; Dr. Shinzo Kassai-Onoda, of the Onoda Cement Co.; and Professor Kaisaku Shibata, of the Imperial University at Tokio.

Work of International Commissions.

International Commissions of this description naturally work very slowly, and the resolutions they arrive at are rarely unanimous, but their great advantage is, that they generally get together an enormous amount of valuable information, which, if properly summarised, becomes invaluable as comprising the reliable and authentic data of the points at issue.

In both the cases of the International Commissions here referred to the question of presenting useful data is one of importance, and reliability the great factor. We doubt if the Commissions on Reinforced Concrete Accidents can come to any other result beyond a presentation of the primary causes of accidents, but in the case of the Commission on the Fire-Resistance of Concrete and Reinforced Concrete it is to be hoped that some standard specification may be evolved—much on the lines of the Fire Insurance Specification we have referred to in a previous issue, and which, in a few short words, indicates on general lines only what is absolutely essential from the fire point of view.

A Warning to the International Testing Association.

The International Testing Association has done much good work in forming these International Commissions, and the reports of some of the Commissions in particular have been of immeasurable value. There is some danger, however, that they should touch on subjects that may be controversial from the industrial aspect, and for this reason International specifications on such subjects as Portland Cement—or on the qualities of Steel and other metals—should be avoided, more particularly as such subjects are dependent generally on local conditions and local mineral products.

Now that a British section has been properly organised to represent British interests in the International Testing Association, it is to be hoped that this aspect of the Association's work will have proper attention, for there was a tendency—particularly on the part of the multitude of German members who rather strenuously represent the interests of their nation on this particular organisation—to utilise the International Commissions for the commercial purposes of their country.

We welcome the formation of Research Commissions such as the ones referred to above, but shall be very wary of anything in the way of Commissions that attempt the international specification of our national products—generally to the disadvantage of our country.

SIR HENRY TANNER.

We observe that the public Press has announced that Sir Henry Tanner, C.B., has retired from his post as principal architect to H.M. Office of Works, after some forty-two years' service with that department. His present post he has held since the retirement of the late Sir John Taylor in 1898.

Fortunately, however, we are able to announce that His Majesty's Government has very wisely retained the services of Sir Henry Tanner in a consultative capacity, so that although he may not be in that hourly attendance at Storey's Gate which is almost necessary nowadays for one holding the position of chief architect, and although Sir Henry Tanner will be free from that incessant grind of routine work which is becoming more and more a feature of modern methods of administration, the Government and the country will have the great and inestimable benefit of his continued advice.

Thus it will not be for us, as so many of our contemporaries have done, to write at this moment of Sir Henry Tanner as having severed his connection with public life, but simply to congratulate him upon the conclusion of a term of public service in which he has been not only a conspicuous figure, but which he has made memorable by his broad-minded and practical decisions in many matters of the highest possible technical moment. Not least among these decisions was the unique one whereby reinforced concrete was introduced into Government buildings, regardless of the conservatism—not to say opposition—that prevailed in this matter both in Great George Street and in Conduit Street, the homes of the Institution of Civil Engineers and the Royal Institute of British Architects.

Sir Henry Tanner is, as far as Government work is concerned, the pioneer architect in England to undertake any really great enterprise with this form of construction, but if he was a pioneer in his own department, he was also a great leader and most tactful and conciliatory adviser on the many committees with which his name was associated which dealt with reinforced concrete. We would remind our readers particularly of his chairmanship of the Reinforced Concrete Committee of the Royal Institute of British Architects, his office as president of the Concrete Institute, his seat on the Reinforced Concrete Committee of the Institution of Civil Engineers.

It is to be hoped that the subjects of concrete and reinforced concrete will continue to have Sir Henry Tanner's valuable advice and wise advocacy and support. Perhaps with the lesser ties of time he will even be able to give yet more time to these subjects in the future than in the past.

OUR CONCRETE COTTAGE COMPETITION.

We desire once more to remind our readers of the Concrete Cottage Competition which we have organised and in respect to which competition designs have to reach us by May 15th.

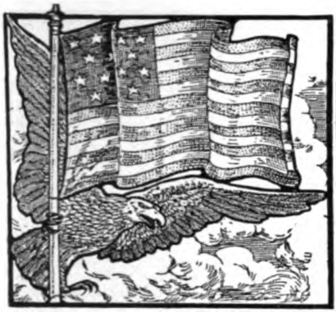
Particulars of the competition are obtainable upon written application, and we suggest that all directly or indirectly concerned in this important problem should use their influence to obtain the co-operation, in this competition particularly, of the younger architects, to whom the matter of a successful design and the publicity that will be accorded it should be of considerable utility.

Probably over 100,000 cottages will be required during the next few years for our rural population, and it is not improbable that both for practical, hygienic, economic and local reasons a considerable proportion of these will be erected in concrete.

The interest that has already been accorded to this competition by great landowners and their agents, by public authorities and their officials, and by the public Press, shows us that there is a very great demand for a suitable design.

The problem is one of the most far-reaching importance, for it affects not only the well-being of the rural community and the tilling of the land, but it affects many of the great industries concerned in the cheaper forms of building construction, and thus the problem is essentially one of £ s. d.

The reasons for our arranging this competition we have already given and we trust that by the 15th May we shall find that our object has been achieved by competitors producing designs of real practical utility. As to the prizes we offer and the arrangements we have made as to assessors, we would refer to our advertisement columns.



CONCRETE MASONRY IN THE PANAMA CANAL.

(Conclusion.)

By JOHN GEO. LEIGH.

This article is continued from our March issue.—ED.

Concrete has entered largely into the construction of the line by which electrical energy will be transmitted from the hydro-electric generating station at Gatun to load centres at Cristobal, nearer the Atlantic, and Miraflores and Balboa, on the Pacific side. The line runs completely across the Isthmus, parallel with the right-of-way of the Panama Railroad, and will be used for the distribution of energy for light and motive power at the terminal docks, locks, etc. For this line there will be required 917 steel bridges, having a span between side frames of 36 ft., and spaced on 300 ft. centres. The standard concrete foundation, the type of which has been carefully studied, consists of two pedestals resting upon a spread slab, which latter is reinforced by

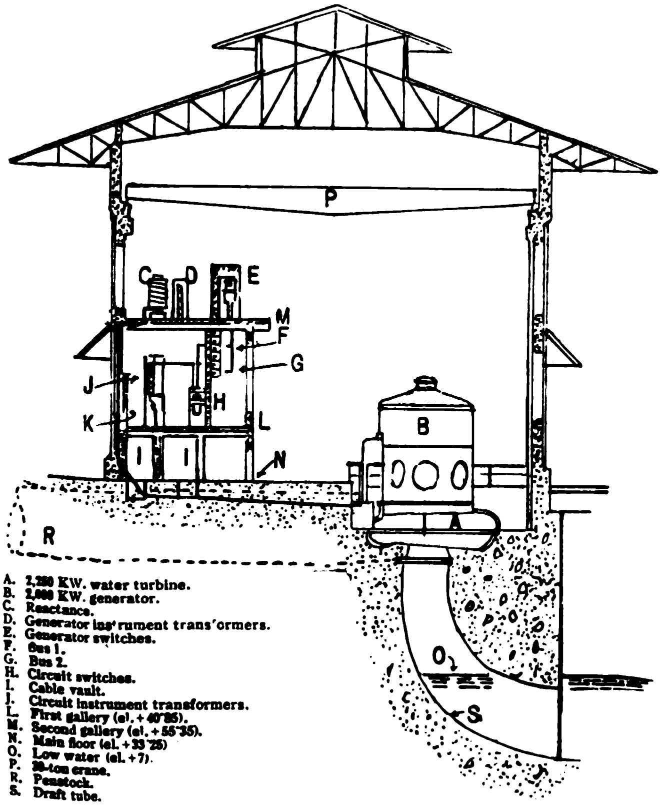


Fig. 9. Section through Hydro-Electric Station.
CONCRETE MASONRY IN THE PANAMA CANAL.

scrap steel rails. Each leg of the side frame is secured to the pedestal through two 15-in. anchor bolts, which are clamped at the lower end to the steel rails in the spread slab. Provision for anchoring the foundations is made by extending downward long reinforcing rods, encased by concrete in a drilled hole, sprung at the bottom with light charges of dynamite.

Exhaustive studies have been made to secure at the various locks not only a distribution of light best suited to the conditions, but also adjuncts calculated to satisfy æsthetic demands. Finally, after approval by the Fine Arts Commission, the type of standard and bracket illustrated in *Fig.* 10 was adopted for exterior illumination. The lamp used is a large power tungsten bulb (400 watt), set in a concrete hood, the standards being aligned longitudinally and transversely and the lamps spaced on from 50 to 60 ft. centres. Both the pedestal and column contain a large core, which reduces the weight and furnishes a runway for the electric wires. About 3½ yds. of concrete and 750 lb. of steel reinforcement have been required in the construction of each of the standards, and of the latter there have been erected at Gatun Locks 211, at Pedro Miguel 131, and at Miraflores 160, some having single and others double-arm brackets. Each double-arm bracket, with reflectors, weighs approximately 1,612 lb., and the solid ball finial, weighing 750 lb., is used to counterbalance the weight of the single-arm bracket.

The single bracket standards are used on the centre walls, where the lamps are staggered so as to illuminate both lock chambers, the double brackets being placed on the side walls, where it is desired to throw the lighting flux back of the chamber for a considerable distance. The reflectors are cast of concrete and provided with shading hoods, which prevent the glare of the lamp filament from penetrating along the axis of the Canal. The entire reflector, with lamp and socket, is waterproof and fitted to resist in every respect tropical deterioration.

The lamps in the operating tunnels and machine rooms in the lock walls are also

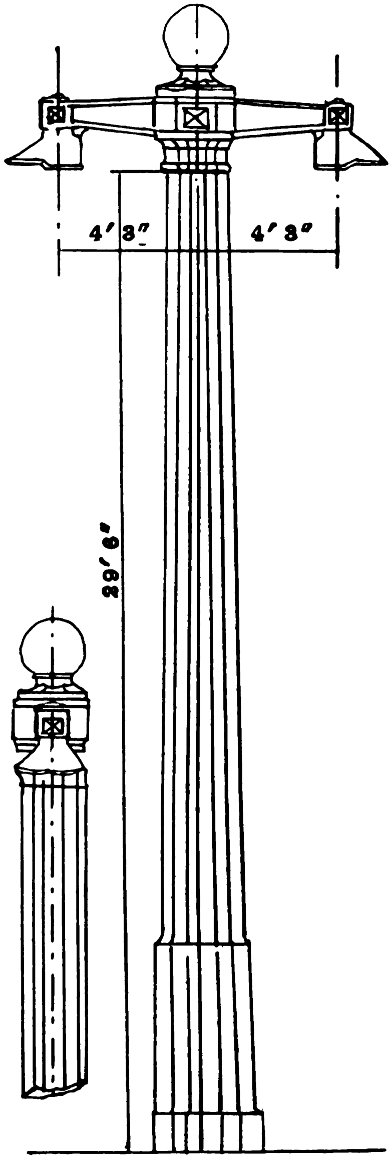
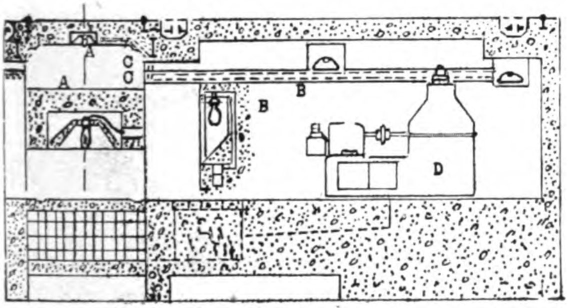


Fig. 10. Reinforced Concrete **Lamp Standard** and Bracket.

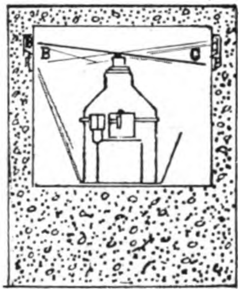
CONCRETE MASONRY IN THE PANAMA CANAL.

provided with specially designed concrete reflectors, and recent experiments have gone far to demonstrate the efficiency of the arrangements which have been adopted. In the tunnel lighting the greatest trouble was occasioned by the low head-room of 7 ft., which made it difficult to secure uniform illumination at the floor line. This obstacle has been overcome by placing ceiling lamps on 15-ft. centres along the longitudinal axis of the tunnels, and by providing them with reflectors of comparatively simple design consisting of inclined surfaces at the four sides. In the machine rooms it was necessary to depend upon side-wall illumination, for which purpose recesses were cast in concrete at about the level of the eye, and the efforts of the designers were directed towards shading direct rays from the eye without detriment to the effective lighting of the machines. The solution arrived at, illustrated in *Figs.* 11 and 12, was to set the lamp socket in the top of a concrete reflector, grouted into the wall recess, the wires being brought to the lamp through a chase in the wall. In front of the lamp is placed a concrete shade, containing a semi-circular opening at the bottom, and adjusted in a vertical plane so as to cut off the direct glare of the filament and permit the lighting flux to penetrate through the opening and flood the machine. There will be altogether 2,041 tunnel reflectors—952 at Gatun Locks, 412 at Pedro Miguel, and 677 at Miraflores—and 4,751 machine-room reflectors, thus distributed—Gatun 1,524, Pedro Miguel 1,126, and Miraflores 1,524.



A. Concrete reflector for ceiling lamps. B. Reflector for wall lamps. C Chase for wiring. D. Cylindrical valve machine.

Fig. 11. Operating Tunnel in Lock Walls.



B. Reflector for wall lamps.
C. Chase for wiring.

Fig. 12. Detail of Tunnel Reflectors.

CONCRETE MASONRY IN THE PANAMA CANAL.

CONCRETE ARCHES AND WALLS AT LOCKS.

To the future traveller through the locks few features of the construction of the latter will appear more pleasing than the arches at the south end of the chambers, connecting the walls of the locks proper with the guide and flare walls of the approach. They are light and graceful in appearance and provide an agreeable contrast to the necessarily plain and massive walls of the lock chambers. In each flight the purpose of these arches is the same, namely, to serve as a bridge over which the electric locomotives will pass when towing a ship through the locks. At Pedro Miguel the side wall arches, illustrated in *Figs.* 13 and 14, make a continuous bridge from the main lock walls at elevation 92 ft. above sea-level to the wing walls at elevation +67 ft. The upper arch contains about 1,093 cub. yards of concrete and the lower about 1,021 cub. yards, while the arch in the centre wall contains about 1,850 cub. yards. There are in each side wall arch about 27,676 lb. of reinforcing steel—60 bars 1¼ in. square and 92 and 82 ft. long, while the centre wall contains reinforcement weighing 47,100 lb. The width of the arches in the side walls is 31 ft. and in the centre wall 54 ft., the length of span of each arch being 79 ft., the minimum thickness of crown 5 ft., the radius of intrados 90 ft., and the rise of arch 9 ft. 2 in.

Owing to the character of the foundation, a portion of one of the southern guide walls at Gatun locks differs in construction from that of other similar works along the Canal line. The wall extends into the Lake 1,500 ft. from the upper guard gates, and the south, or outermost, 850 ft. rest on light earth, bed rock being about 150 ft. below the surface. This portion, therefore, is constructed upon piles driven from 35 ft. to 70 ft. into the ground; and to reduce the weight on them as much as possible the wall takes the form of a reinforced concrete cellular structure. The wall is founded on a concrete slab, from 4 ft. to 5 ft. thick, laid over the tops of the piles, and is 58 ft. wide and 67 ft. above the ground, which is here 32 ft. above sea-level. The outside shell

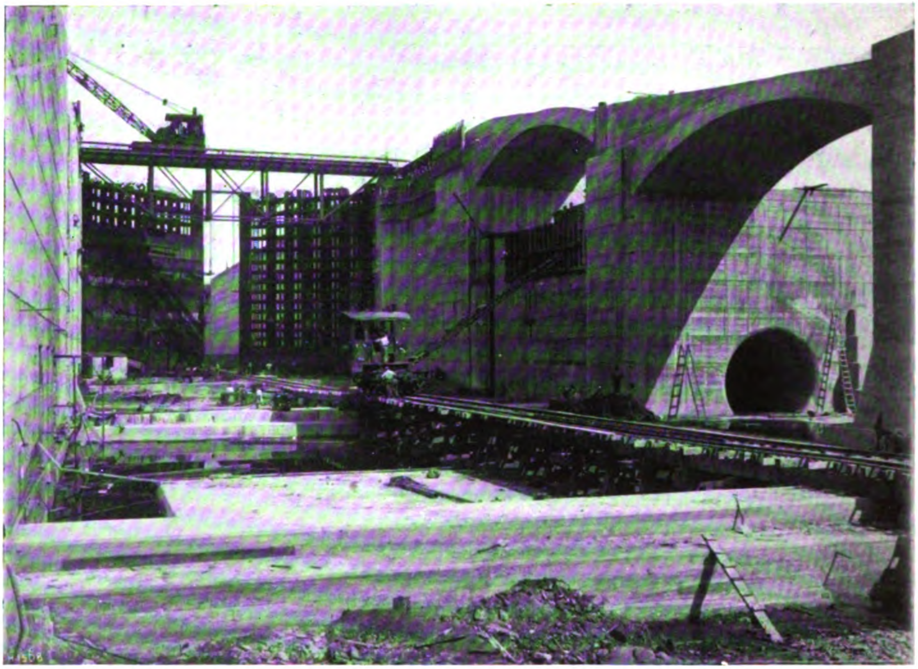
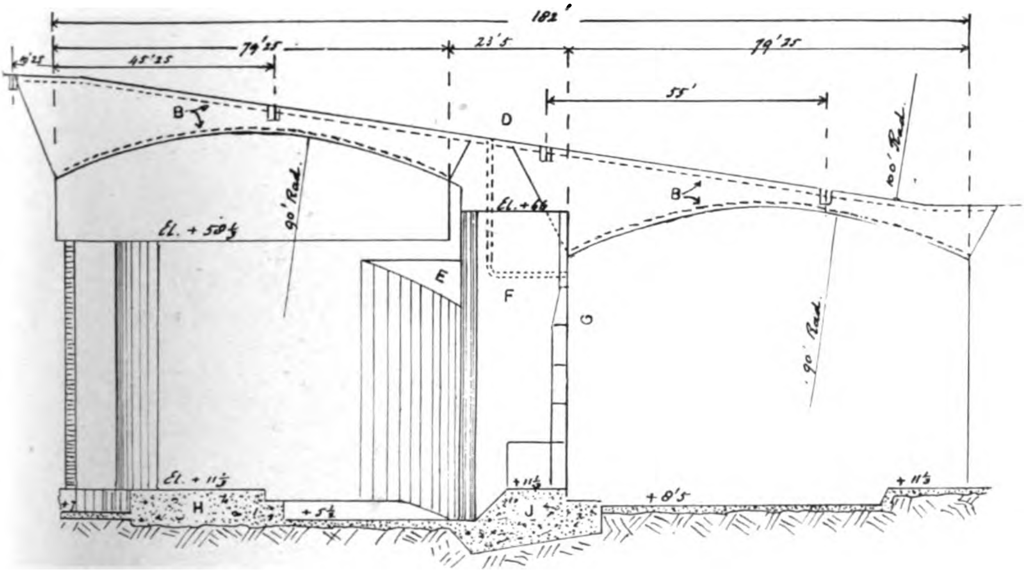


Fig. 13. Pedro Miguel Locks, showing Outlet in East Wall and Construction of Lower Main Gates.

CONCRETE MASONRY IN THE PANAMA CANAL.

is a reinforced concrete wall, 2 ft. thick, within which are two 18-in. walls 17 ft. apart, running the length of the guide wall, and fifty walls of the same thickness crossing from side to side at regular intervals of 15 ft. Thus the interior consists of a series of cells, 15 ft. by 17 ft., separated by 18-in. partitions. In the cellular portion of the wall about 35,000 cub. yards of concrete have been placed.

Modifications of the prevailing method of construction have also to be noted in connection with the lower approaches to the locks. The upper approach walls for all the locks are of reinforced concrete in cellular structure, but for the lower walls at Gatun and Miraflores—with a view to avoiding any possibility of corrosion of the steel reinforcement by sea water—only mass concrete has been used. At Gatun the desirability of variation was enhanced by the relatively insecure foundation, for, after excavation had been carried 50 ft. below sea-level, the use of long piles was found necessary to reach rock, in some places 50 ft. further below. The structure planned to meet these conditions and replace the heavy U-section, double gravity walls at Pedro Miguel and Miraflores consists of a series of piers, connected by flat spans above, forming a causeway of successive bridges. To protect them against transverse sliding, the piles, which are driven on 4-ft. centres, longitudinally and transversely, and on 3-ft. centres for the outermost 200 ft., are surmounted by a continuous base of concrete, extending 1 ft. below the top of the piles.



B. 1¼ in. sq. Bars 12 in. c c.
D. Cross drain.
E. 45° Slope.
F. 12 in. Drain.
G. Caisson seat.
H. Lower guard gate sill.
J. Caisson sill.

Fig. 14. Side Wall Arches, Pedro Miguel Locks.

CONCRETE MASONRY IN THE PANAMA CANAL.

This base is 58ft. wide. The bottom is level, but the top is a series of inverted stepped arches, described on a radius of 42 ft., the haunches between which form the bases of the piers of the flat-span bridge. At the lowest step of the arches the thickness of the base is 5 ft. 7 in., but at the springing line it is 3 ft. more. Reinforcement in the base consists of twenty continuous longitudinal rows of 70 lb. rail, resting on the top of piles, and duplicate rows of similar rail 4 ft. 6 in. higher up. The side elevation of the base and of a portion of the completed wall is illustrated in *Fig.* 16.

Fig. 17 is a transverse section of the wall. Each pier, it will be noted, consists essentially of two piers, connected by a semi-circular arch. The horizontal normal section of each component is 18 ft. by 10 ft.; the inner sides are vertical for a height of 22 ft. 5½ in., this point above the base being the springing line of the arch. On the outer faces the piers are vertical from the base, at elevation – 39·44, to the top, which is 12 ft. above sea-level. The piers, twenty in number, are set 50 ft. apart, centre to centre, the spans connecting them being carried by four 6-ft. and six 4-ft. 6-in. plate girders, encased in concrete. To prevent water from surging from one approach channel to the other, when a lock chamber is discharging, the six spans of wall nearest the locks are closed by 26-ft. curtain walls. The wall extends 1,016 ft. from the line of fender chains, and contains about 45,000 cub. yards of concrete.

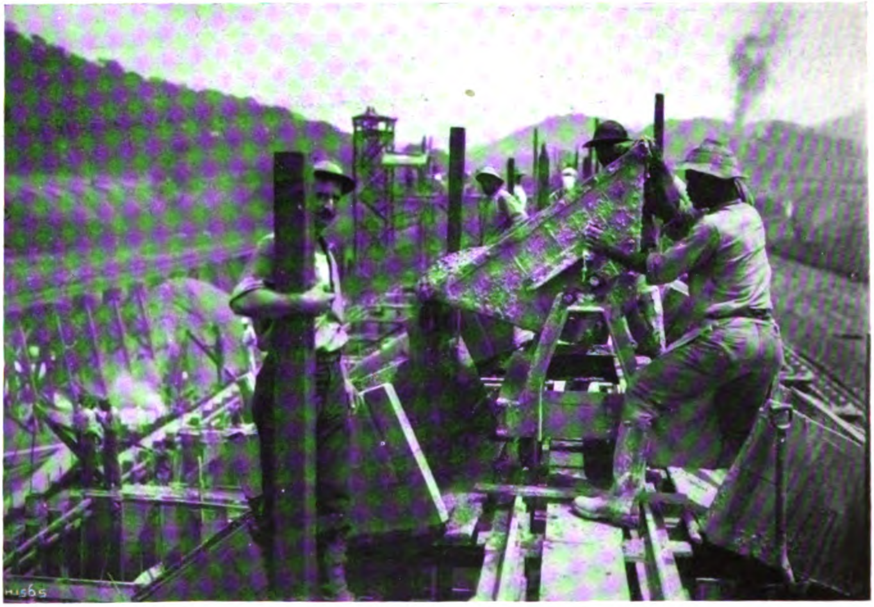


Fig. 15. Construction of the North Approach Wall, Pedro Miguel Locks; view showing method of placing concrete.

CONCRETE MASONRY IN THE PANAMA CANAL.

The corresponding structure at Miraflores, extending into the Pacific entrance channel, takes the form of two walls, back to back, with a space of

8 ft. between bases, and with faces in continuation of the centre wall. The outer ends are joined by a concrete wall, 8 ft. thick, perpendicular to the parallel walls, and the space thus enclosed is filled with rock and screenings, the decking being laid over the top. This structure, which contains 82,000 cub. yards of concrete, differs from the lower approach wall at Pedro Miguel in that the bases of the parallel walls do not touch and that each of these walls rests on rock, with a toe along the outer side about 10 ft. wide at base laid in excavation carried to elevation -50 ft. From the edge of the toe the wall batters inward, 1 on 3, to a height of 9 ft., and from this point rises vertically for 54 ft., a few inches at the top battering inward, 1 on 3, to form coping. The rear, or inner, sides of the walls are stepped in, at intervals of 6 ft., from a thickness of 26 ft. 6 in. at base to 8 ft. at top. Corbels, supported on the steps 6 ft. and 12 ft. below the top, project inward to a distance of 14 ft. from the face of the wall, to support the superincumbent decking and electric locomotive towing rails. At Pedro Miguel the wall is of mass concrete for 950 ft. from its juncture with the centre wall, the remaining 250 ft. being of reinforced concrete.

DETAIL COST PER UNIT OF WORK.

Not the least interesting and valuable record of the activities of the Canal Commission will be found in the reports of the Cost-Keeping Accountant. The cost reports compiled prior to January 1st, 1910, included comparatively little detail, except for excavation work, and were not available until five or six weeks after the close of each month, nor did they contain any charge for plant and equipment, such expenditures being carried into the accounts in total only. With the commencement of concreting, however, it became apparent that some method should be adopted by which the sums expended in developing quarries and sand pits for the production of material and in providing mixing and other machinery would be absorbed in the cost of the product, to the end that all expenditures incurred for preliminary work, machinery, and installation would be taken up in the cost of the masonry.

Consequent upon recognition of the importance of such measures, a cost-keeping system was devised which has provided a uniform classification in the various construction divisions, identical items of expense entering into the cost of each division for work of like character. A system of arbitraries, revised semi-annually when necessary, was also adopted with a view to the absorption into the construction cost of all expenditures for plant and equipment, based upon the estimated cost and the estimated amount of work to be accomplished, and wholly ignoring any salvage which might be realised after the completion of the latter. In order, also, to state the accounts uniformly, the plant arbitraries were applied to all construction work prior to the date on which the system became effective.

By means of this system complete control has been obtained over expenditure for labour, material and services. The labour costs have been prepared from the daily reports of foremen in charge of the gangs, and balanced against the monthly pay rolls, and the costs for material have been obtained from the orders drawn on the storehouses, balanced against the chief quartermaster's reports of the value of material issued. Sand, stone and cement have been priced at the

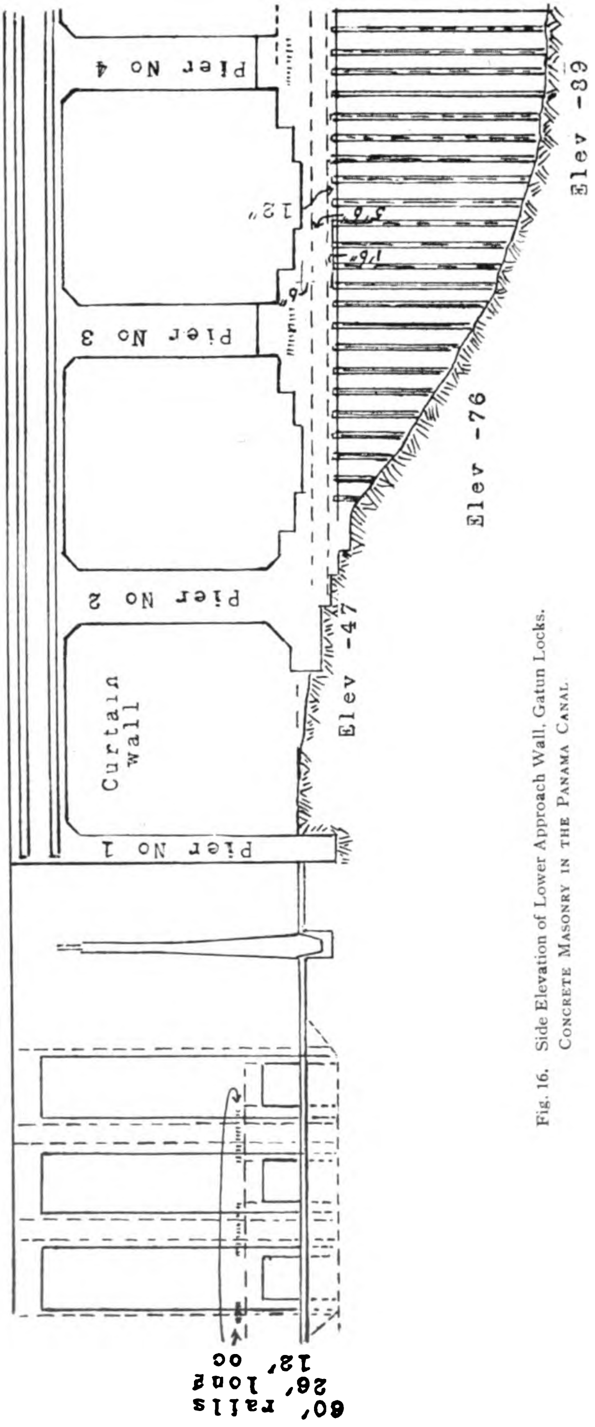


Fig. 16. Side Elevation of Lower Approach Wall, Gatun Locks.
Concrete Masonry in the Panama Canal.

cost of delivery at the warehouses or storage piles, the prices of the two first being based upon the monthly output and the expenditure connected therewith. The price at which the material has been charged into the work is the average resulting from the cost of the quantity left in storage at the close of the preceding month and the cost of production during the month. In the detailed statements of costs all expenses are included other than the proportions representing expenditures for sanitation, hospitals, civil government, lands purchased, terminal docks and wharves, relocation of the Panama Railroad, purchase of steamers, construction and repair of buildings and municipal improvements in Panama, Colon and the Canal Zone.

The total amount of concrete laid during the fiscal year 1910-11 was 1,742,928 cu. yd., distributed as follows:—Gatun Locks, 911,137 cu. yd.; Gatun Spillway, 59,651 cu. yd.; Central Division, 1,020 cu. yd.; Pedro Miguel Locks, 498,187 cu. yd. and Miraflores Locks, 272,933 cu. yd. Taking into consideration differences in the length of the working day, the average amount of masonry placed daily in the locks by the Atlantic Division was 260·573 cu. yd., and by the Pacific Division 281·299 cu. yd. The cost per cu. yd. at Gatun Locks was $6.5919, at the Spillway $6.7044, at Pedro Miguel Locks $4.7040, and at Miraflores $4.6826. At Gatun the use of 73,609 cu. yd. of large rock resulted in a saving of $0.2888 per cu. yd. of material placed. The cost of stone in bins at Gatun was $2.3403 per cu. yd., and in the storage pile for the locks on the Pacific side $0.8443 per cu. yd. Crushed stone from Porto Bello was transported to Gatun by barges, and unloaded by cableways and derricks, while from Ancon quarry the crushed rock was carried by rail to storage and dumped from trestles. The difference of $0.7184 in the cost of these two methods deducted from the actual cost in storage left $1.3219 per cu. yd. as the unit cost of Porto Bello stone at Gatun. Sand for the locks on the Pacific side was secured at Chame, in the Bay of Panama, towed twenty miles, unloaded by electric cranes, and delivered in storage at a cost of $1.8565 per cu. yd., while sand for Gatun was brought from Nombre de Dios and unloaded by cableways. Omitting the cost of transportation from the sand-banks to the docks, the cost to the Atlantic Division was $1.3172 per cu. yd., and to the Pacific Division $0.6015. Taking into account the various conditions, the year's operations showed a difference in favour of the Miraflores Locks of $1.7340 in the cost of cement, sand, stone, and large rock; of the Pedro Miguel Locks in respect of other items which went to make up the cost of the finished product—*e.g.*, forms, placing, pumping, power, repairs, plant arbitrary and division expenses, and of the Atlantic Division in mixing and reinforcement.

There were placed in the locks and spillways during 1911-12 1,443,570 cu. yd. of masonry. The unit costs of this work were: At Gatun Locks, $7.7552; at Gatun Spillway, $7.0988; Pedro Miguel Lock, $6.4640; and Miraflores Locks, $4.7675. Thus, with a decrease of 512,315 cu. yd. laid in Gatun Locks, the cost of plain concrete rose $0.5398 per cu. yd. as compared with the previous year. At Pedro Miguel, also, where the amount laid was less by 363,609 cu. yd., there was an increase in cost of $1.0143 per cu. yd., due to forms, placing, mixing and arbitrary. On the other hand, at Miraflores, where the amount placed was 456,163 cu. yd. greater, the cost of plain concrete was $0.0959 less. The labour costs for the year per cu. yd. were lowest at Miraflores, namely, $0.8394, Gatun Locks coming second with $1.3840, Pedro Miguel Lock third with $1.4733, and Gatun Spillway next with $1.5425. The difference between the costs in the Atlantic and Pacific divisions may be attributed mainly to the cost of cement, sand and stone. The cost of stone at the storage piles at Gatun was $2.4952, as against $0.7996 per cu. yd. in the storage piles for the locks on the Pacific slope. If, however, there be deducted from this difference of $1.6956 the extra expense attached to the Porto Bello stone, represented by the difference ($0.7365) between the costs of towing and unloading and those of transportation by rail, together with the difference in plant arbitraries, amounting to $0.4336, it will be found that the net difference in labour costs in favour of Ancon quarry was actually $0.5255 per cu. yd. Sand procured from Nombre de Dios and from the Chagres river beds cost respectively $2.2414 and $1.2850, delivered at the stock piles of the Atlantic

Division, as compared with $0.7025, the cost per cu. yd. of the sand gathered at Chame and towed to Balboa.

ANALYSIS OF CONSTRUCTION EXPENDITURES.

The classified expenditures of the Canal Commission to December 31st of last year amounted to £64,892,105, of which about £40,442,865 was apportioned to the Department of Construction and Engineering, £18,413,000 to "general items," £3,479,450 to the Department of Sanitation, and £1,395,000 to the Department of Civil Administration. From the latest available statement of details (that to September 30th) of construction expenditures, amounting in the aggregate to £40,670,000, I note the following particulars :—

Excavation and dredging of Canal prism : From and including Gatun to the sea, 39,901,753 cu. yd., cost £2,118,330; from Gatun to Pedro Miguel, 109,624,594 cub. yd., total cost, including masonry and £15,600, value of plant and equipment to be absorbed in construction costs after September 30th, £17,690,000; from and including Pedro Miguel to the sea, 45,228,233 cu. yd., total cost £3,000,000.

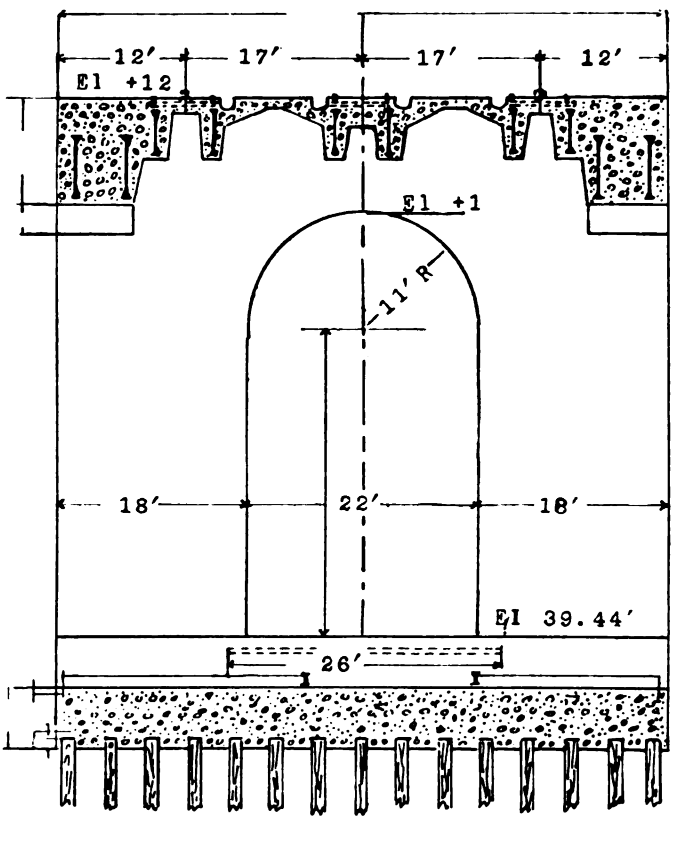


Fig. 17. Sectional View of Dual Pier.
CONCRETE MASONRY IN THE PANAMA CANAL.

Gatun Spillway : Excavation and preparing foundations, 1,588,921 cu. yd.; masonry, 229,873 cu. yd., cost £377,000, unit cost $7.9548; ironwork, gates and operating machinery, £73,235; total cost, £700,000.

Gatun Dam : Total cost, £1,783,000.

Gatun Locks : Cost of excavation and preparing foundations, including 83,670 lin. ft. concrete piles, £934,860; mass masonry, 2,041,156 cu. yd., cost £3,139,217, unit cost $7.4591; masonry used in installation of machinery, 23,011 cu. yd., cost £63,857, unit cost $12.3828; total cost, including gates, fender chains, operating machinery, etc., £5,000,000.

Gatun hydro-electric station and plant: Cost £95,000.

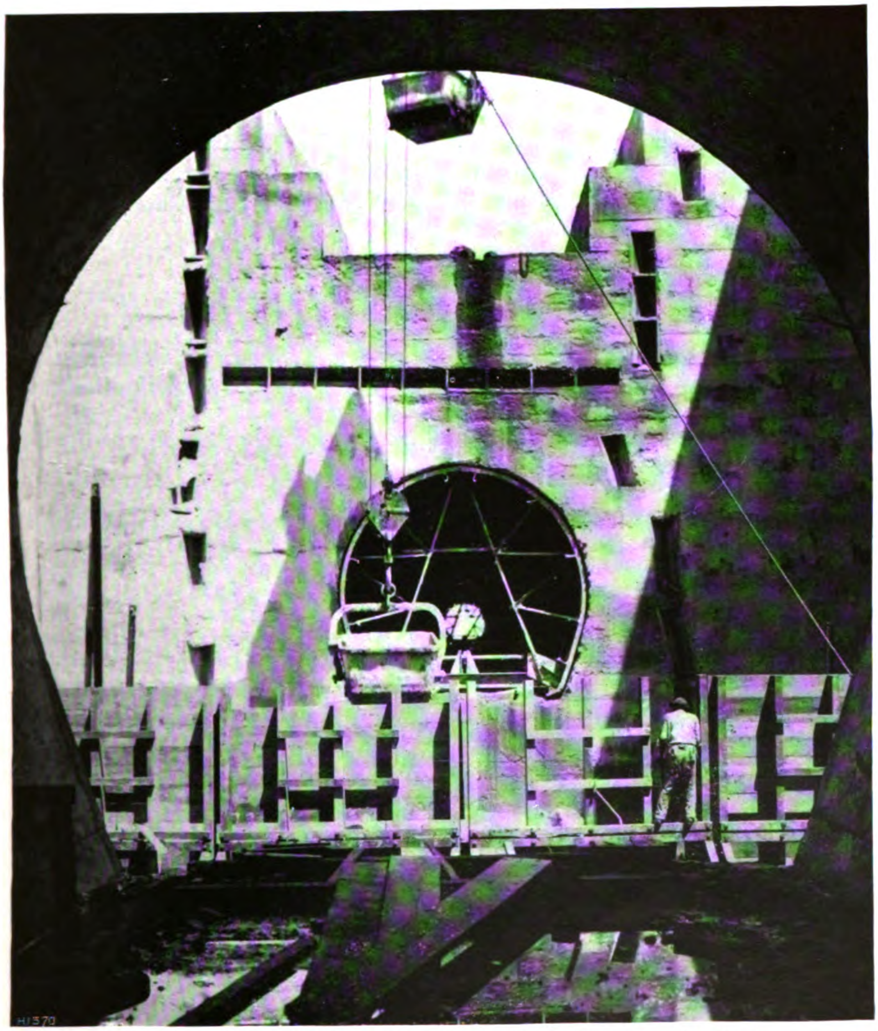


Fig. 18. **Laying Concrete, Gatun** Upper Locks; view from a centre wall culvert.
Concrete Masonry in the Panama Canal

Gatun to the sea: Total construction cost, including £58,670, plant to be absorbed in construction costs, £11,324,000.

Pedro Miguel Dams: 1,567 cu. yd. masonry, unit cost $5.3872; total cost, £75,200.

Pedro Miguel Locks: Cost of excavation and preparing foundations £311,560; mass masonry, 906,554 cu. yd., cost £1,099,600, unit cost $5.8838;

masonry for machinery installation, 14,576 cu. yd., unit cost $11.9716; total cost, including operating machinery, etc., £2,413,000.

Miraflores Dams and Spillway: Excavation, 159,130 cu. yd.; masonry, 77,925 cu. yd., cost £108,405; total cost £384,220.

Miraflores Locks: Cost of excavation and preparing foundations, 3,286,800 cu. yd., £671,585; mass masonry, 1,479,079 cu. yd., cost £1,634,483, unit cost $5.3596; masonry for machinery installation, 16,984 cu. yd., unit cost $11.5411; total cost, including iron work, gates, emergency dams, operating machinery, etc., £3,456,330.

Pedro Miguel to the sea: Total cost, including excavation and part construction of the abandoned locks and dams at La Boca, construction of the Naos Island breakwater and about £200,000, value of plant and equipment to be yet absorbed, £9,800,000.

Terminal facilities at Cristobal: £18,360.

Terminal facilities at Balboa: Part cost, including £57,275, value of plant and equipment to be absorbed, £667,470.

Miscellaneous items: Permanent town sites, Balboa, La Boca and Pedro Miguel, permanent buildings, power transmission line, trans-isthmian oil-pipe line, and lights and buoys, £202,000.

In the final quarter of the financial year 1912-13 the cost per cu. yd. of the masonry placed in the several locks was as follows:—

	Gatun. $	Pedro Miguel. $	Miraflores. $
Concrete	6·1208	93·4848	7·7140
Administrative and general expense ...	·4444	9·8458	1·4693
Total cost	6·5652	103·3306	9·1833
Reinforced masonry	9·1382	14·4834	9·7500
Administrative and general expense ...	1·0252	3·3165	2·0551
Total cost	10·1634	17·7999	11·8051

The exceptionally high cost of masonry during this quarter was due to charges for finishing work, clearing the lock floors, etc., these special expenses being proportioned to "Wood forms," "Mixing," and "Placing."

The progress, month by month, of masonry construction at the various locks is indicated in the following tables:—

GATUN (cu. yd.).

	1909.	1910.	1911.	1912.	1913.
January	—	54,136	72,919	34,983	28,085
February	—	55,696	72,103	26,664	30,780
March	—	60,998	86,884	27,532	48,180
April	—	63,227	67,361	11,600	22,732
May	—	74,273	67,844	7,746	13,046
June	—	89,401	55,035	6,095	5,509
July	—	84,001	71,046	8,093	3,431
August	1,298	85,686	66,928	6,855	6,258
September	12,294	76,720	57,298	3,162	442
October	29,378	86,949	53,636	3,252	174
November	30,270	75,152	43,907	6,029	280
December	42,832	80,212	43,590	5,697	120
Total	116,072	886,451	758,821	147,708	159,037
Grand total			2,068,089		

PEDRO MIGUEL (cu. yd.).

	1909.	1910.	1911.	1912.	1913.
January	—	16,273	38,513	15,003	4,652
February	—	13,218	37,011	12,639	4,294
March	—	18,793	44,716	9,331	13,412
April	—	24,522	28,635	9,460	2,145
May	—	29,576	19,135	10,736	1,144
June	—	30,631	18,243	10,061	773
July	—	41,464	19,906	11,480	1,829
August	—	51,264	20,736	5,995	1,884
September	2,370	50,702	15,379	3,039	1,144
October	8,310	61,422	25,637	6,587	412
November	10,169	64,248	19,622	7,972	630
December	13,007	42,834	14.360	6,958	1,162
Total	33,856	444,947	301.893	109.261	33,481
Grand total			923,438		

MIRAFLORES (cu. yd.).

	1909.	1910.	1911.	1912.	1913.
January	—	—	24,018	48,416	50,456
February	—	146	20,896	63,893	34,979
March	—	314	31,173	83,706	21,030
April	—	13	38,758	97,735	13,266
May	—	27	36.154	92,095	6,956
June	—	1,603	26.536	68,398	3 836
July	28	3,672	32,840	66,026	3,810
August	74	6,030	57,003	75,388	3,643
September	—	18,133	56,083	46,122	1,907
October	—	22,159	60,873	54,790	1,152
November	—	23,871	41.726	39,874	2,007
December	—	21,533	48.772	46,746	1,859
Total	102	97,501	474,832	783,189	144,901
Grand total			1,500,525		

CONSUMPTION OF CEMENT.

In view of the impending commencement of lock construction work what is probably the largest single order ever given for furnishing Portland cement was awarded in January, 1909. This called for the delivery, f.o.b. New York, of 4,500,000 barrels, at a minimum rate of 2,000 barrels and a maximum rate of 10,000 barrels a day, with the right to increase the order 15 per cent. On this contract the Atlantic Division received 1,343,757 barrels in wood up to May, 1911, when this method of shipment was changed to bags, as preferred by the Pacific Division from the commencement.

During the period of greatest activity in lock construction the delivery of cement from the United States amounted frequently to 7,000 barrels daily, and a stock supply of from 100,000 to 200,000 barrels was maintained on the Isthmus to provide against delays in shipment. Later, however, the rate of delivery was gradually reduced to about 1,500 barrels a day, a reserve being maintained of approximately 50,000 barrels. In September, 1912, tenders were opened for the supply of an additional 1,000,000 barrels, or of 30 to 15 per cent. more or less at the option of the Commission. The specification also provided for delivery up to July 1st, 1913, of from 2,000 to 5,000 barrels a day, and thereafter, until the completion of the contract, of from 500 to 3,000 barrels. Together with two tenders from other companies, a letter was received from the former contractors offering to continue deliveries as might be needed to complete the work on the Canal at the price—92 cents per barrel net—ruling the earlier contract; and this offer was accepted by the Secretary of War on the recommendation of the Chairman of the Commission.

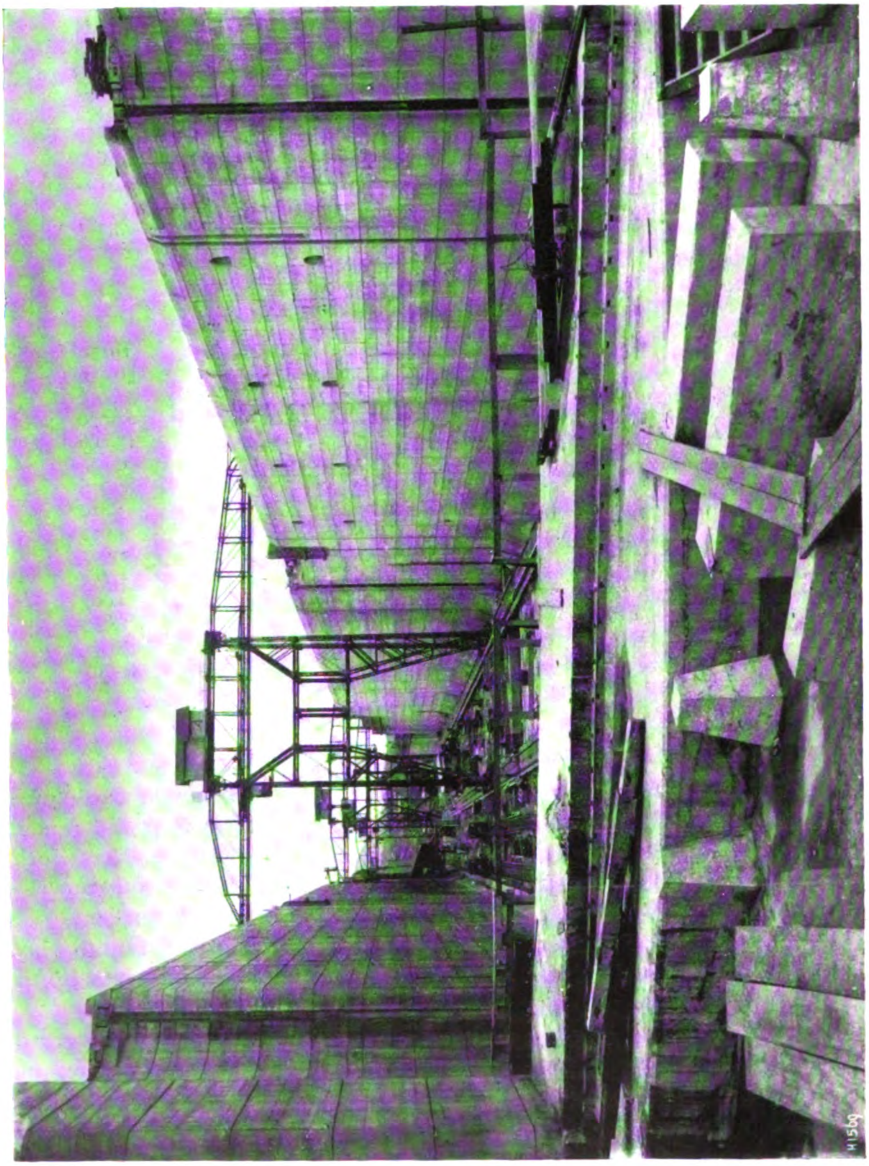
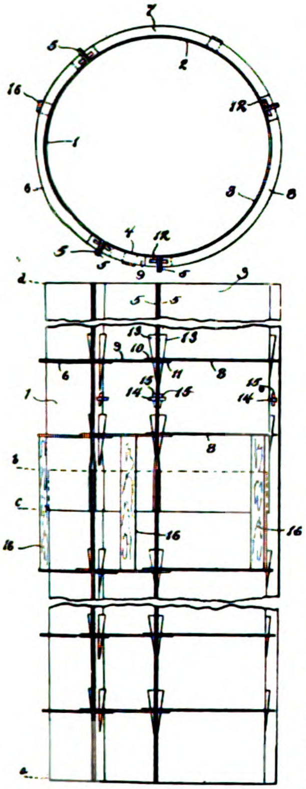


Fig. 19. East Chamber of Miraflores Upper Locks, looking south. Mitre gate sill for upper guard gates in foreground.

Concrete Masonry in the Panama Canal.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. The last article appeared in our issue of October, 1913.—ED.



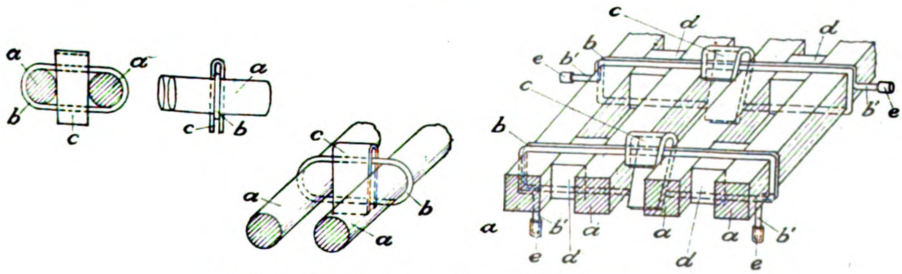
Figs 1 & 2. Column Moulds.

Column Moulds.—No. 5,037/13. *Blaw Steel Construction Company. Accepted November 20/13.*—This invention is applicable to the formation of all kinds of concrete structures circular in cross section, whether solid or hollow.

The invention refers particularly to moulds in which the shell is composed of a number of segmental metal body sections adapted to be assembled together into circular formation, this shell being adjustable to diameter by varying the number of sections used. The invention also comprises improved means for varying the length of the mould, for stiffening the sheet metal plates employed in the construction, and for making them conform to substantially true circular form.

The form or mould (*Fig.* 2) consists of two tubular sections, the lower of which extends from *a* to *b* and the upper from *c* to *d*, but of course as many sections as are necessary may be employed. Either section (*Fig.* 1) is made up of four segmental plates (1, 2, 3 and 4), the plate 4 being a filler plate narrower than the others. The plates are provided at their vertical edges with outstanding flanges 5, the flange of one plate abutting against that of the adjacent one. Extending circumferentially of the plates 1, 2, 3 and 4 are a number of stiffening bands, consisting of substantially arcuate rigid metal plates set edgewise, which serve also to give true circular shape to the columns. This circular band is adjustable to diameter.

Fig. 2 shows two stiffening bands, though any number may be used. As shown (*Fig.* 1) the band is made up of four sections (6, 7, 8 and 9), though any number may be used, depending on the size of the mould and number of plates used. The sections overlap and extend through slots in the opposing flanges 5, 10 and 11 being the overlapping edges of the sections 8 and 9. The overlapping edges of the stiffening ring sections are provided with slots 12 which receive the wedges 13 lying on opposite sides of the vertical flanges 5. When the wedges are driven downward they apply tension to the sections 8 and 9 and



Figs. 1—4. Connections for Metal Reinforcement.

also press the opposing faces of the flanges tightly together. By varying the number of plates employed the diameter of the columns formed may be widely varied.

The plates 1, 2, 3 and 4 are made of relatively flexible sheet metal, and the stiffening numbers 6, 7, 8 and 9 give strength to the mould and also make it conform to an approximately true circular cross section when the stiffening bands are applied. The tension applied by the wedges forces the flexible metal to conform itself to the inner surface of the bands. A set of stiffening bands is provided for each diameter of column, such bands being accurately formed to the desired radius. The bands should be divided into as few sections as is possible without interfering with the freedom of removability of the parts.

In manufacturing the form, the segmental plates are first cut to the proper dimensions, next the slots are punched in the edges, the plates are then rolled to a given curvature and the flanges are then bent back. By this method, using automatic machinery when possible, the plates will be exactly alike.

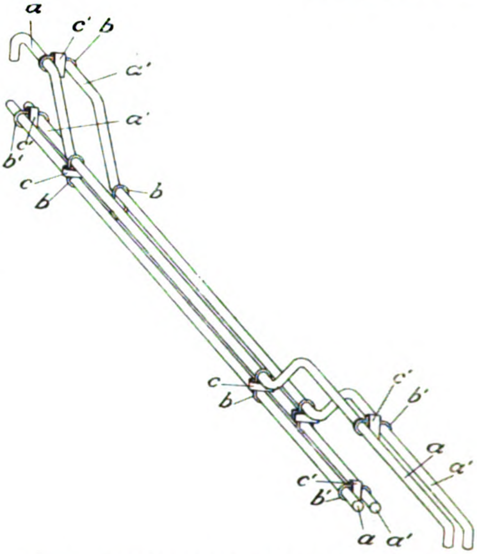


Fig. 5. Connections for Metal Reinforcement.

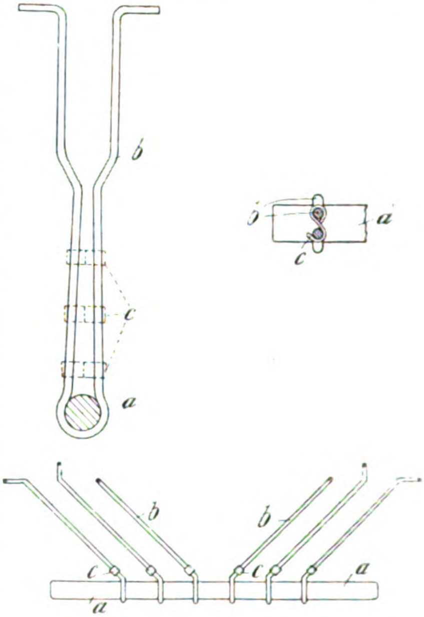
When two lengths of tubular section are used together distance pieces 16 of wood may be employed if any unusual strain is to be imposed on the upper section; ordinarily they will not be necessary, as one section clamps the other securely at the intergaging telescope ends.

Connections for Metal Reinforcement.—No. 2,945/13. *G. W. Stokes. Accepted December* 18/13.—This invention relates to the method of connecting the metal rods or bars used in reinforced concrete constructions.

In the usual method adopted, when there have been two or more rods or bars of iron or steel running longitudinally through the concrete beam, either with or without stirrups, shear members or ties, it has been found that the depositing and ramming of the concrete has displaced the rods in relation to one another and in relation to the outside face of the concrete.

In some cases the rods have been bound together by tying, soldering, clamping, or other means, but this has reduced the area of the metal surface available for adhesion to the concrete, and caused the metal to be less evenly distributed over the cross section of the concrete member.

This invention provides an improved adjustable and rigid lateral connection between two or more longitudinal bars in a reinforced concrete beam, which will keep them at the correct distance apart and also at the correct distance from the face of the concrete member, and will also prevent their displacement during the depositing and ramming of the concrete.



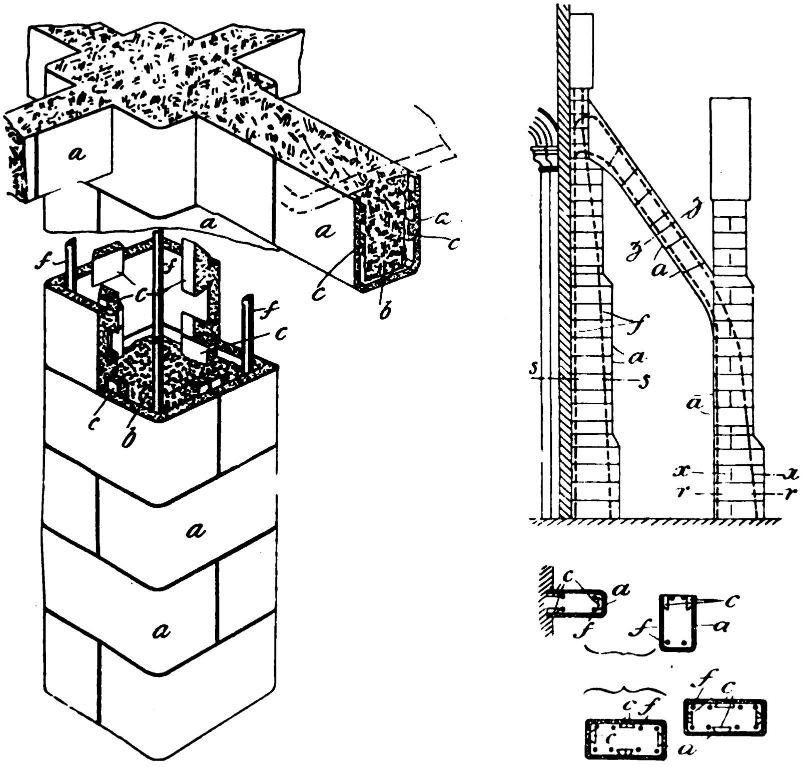
Figs. 1—3.
Adjustable Stirrups for Reinforced Concrete Constructions.

The invention consists in two or more links each surrounding two or more bars, at right angles to the direction of their length and at suitable points, and of two or more wedges, each driven between the two bars with or without distance pieces placed between the bars. Each loop is formed by bending a metal rod of round or other suitable section round a group of two or more longitudinal bars, placed in the exact position which they are designed to occupy in the reinforced concrete beam, or by bending the metal rod round a template, the cross section of which is of the shape enclosed by a flexible thread passed round the outside of the group of bars at right angles to the direction of their length. The ends of the loops thus formed are connected together by welding, twisting, or crossing, and may be continued into the concrete to act as ties, stirrups, or shear members; or they may be bent round another group of bars, or the ends of the loop may be continued until they reach the outside face of the concrete member, to form short struts between the bars and the moulds, thus retaining the bars at the correct distance from the moulds during the depositing and ramming of the concrete.

Fig. 1 is a cross section, *Fig.* 2 a side elevation, and *Fig.* 3 a perspective view of portions of two round longitudinal bars (*a*) embraced by a loop (*b*) and spaced by a driven wedge (*c*) which locks the bars and forms the combination into a rigid frame.

In *Fig.* 4 the loops (*b*) are bent round, or slipped over the four bars (*a*), while their ends (*b*) are extended or bent to form short struts resting on or against the timber or other mould. The distance pieces (*d*) are short lengths of square bar to fit conveniently between the rectangular bars (*a*). The wedges (*c*) are short tapering lengths of flat steel driven diagonally between two of the bars (*a*).

Fig. 5 shows an application of the invention to beam reinforcement. Two



Figs 1-3. Reinforced Concrete and Similar Structures.

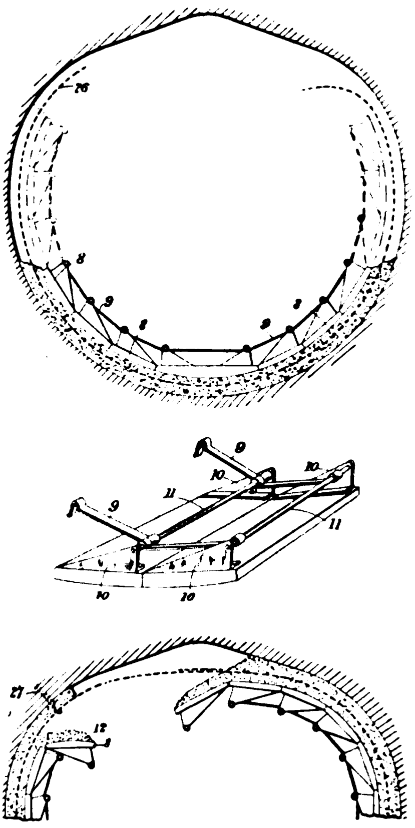
longitudinal bars (a) are rigidly connected and retained at the required distance apart by loops (b) and wedges (c) and together form a unit of two bars. A second pair of bars (a^1) form a similar unit and the two units are rigidly connected by loops (b^1) and driven wedges (c^1) and thus combined form a unit of four bars.

Adjustable Stirrups for Reinforced Concrete Constructions.—No. 16,667/13. *A. A. Storey. Accepted November 27/13.*—This invention relates to an improved adjustable stirrup which can easily be threaded on bars with rough ends or (as is often the case) on bars which vary considerably from the standard sizes.

The stirrups are also locked on the bars in such a manner as to be practically immovable under the rough usage of ramming the concrete.

The stirrup *b, Figs.* 1 and 2, has its legs formed tapered with a terminal loop encircling the main reinforced bar *a*; clips (c) are placed on the tapered legs and driven down tightly, their final position depending on the size of the bar *a*, and therefore allowing some variation in the latter. In *Fig.* 1 there are shown clips in the three positions they would occupy respectively for bars of standard size or slightly above or below it.

The loop of the stirrup may be round or of suitable shape to correspond with the bar on which it is placed, while the stirrups themselves may be either straight or bent as shown in *Fig.* 3 and used in any desired combination.



Figs. 1—3.
Concrete Tunnel Linings.

Reinforced Concrete and Similar Structures.—No. 25,140/13. *J. R. Gwyther. Accepted November 3/13.*—This invention relates to reinforced concrete and similar fireproof structures in which tiles, blocks or the like are used to replace shuttering. The invention consists in an improved method of keying together such tiles, etc.; they are formed of sections provided with projections, preferably dovetailed, on the concrete face, such projections engaging with corresponding ones on the section below.

Fig. 1 shows the application of the invention to a rectangular column with beams running into it. The tiles or blocks (a) are provided with dovetail projections (c) keying into the core, and are held together by a metal strap at the vertical joints.

The beams running into the columns consist of moulded channel-shaped tiles (a) with similar dovetail projections (c). The invention is applicable also to the ordinary fireproof covering of built-up steel sections. *Figs.* 2 and 3 show the application to a concrete buttress provided with metal reinforcement. Single trough-shaped tiles (a) with projections (c) are employed at sections *s—s*, *z—z*, two such sections placed mouth to mouth being employed at the sections *r—r*.

Concrete Tunnel Linings.—No. 21,904/13. *E. R. Calthrop. Accepted September 29/13.*—This invention provides an improved method for lining tunnels and like excavations or borings with concrete. The method consists in progressively building up sections of tubular form by means of shuttering having means whereby the shutters may be so connected together that they are mutually supported without the use of independent scaffolding; two inverted cantilevers meeting at the crown of the tunnel are formed to support the concrete in position, and the latter is vibrated *in situ* to obtain a complete tubular section in which the tensile and compressive stresses are equally distributed throughout when the concrete is set and the lagging removed.

Concrete is laid over the bottom of the tunnel and as far up the sides as practicable, the concrete being mechanically vibrated by any appropriate apparatus to compact the particles together, thus rendering it watertight and preventing the subsequent formation of hair cracks or fissures.

A middle or " key " lagging or shutter (2) is arranged upon the concrete and is exactly centred, such as by a plumb-bob. Further laggings (8) are now placed upon each side of the " key " (2) being temporarily attached thereto and to adjacent laggings by stay rods (9), the laggings being connected to each other by suitable means to prevent them shifting.

Each lagging is provided at its ends with brackets (10, *Fig.* 2) connected by a bar (11) to which are pivotally connected the two stays or struts (9), the free ends of which are so formed as to engage with the bar (11) of an adjacent lagging, and so rigidly connect the two together.

The laggings being connected together, as, for instance, by the aforesaid hinges, up to the point where the walls begin to curve upwards and inwards, concrete is then filled in behind them and vibrated as before, and the building up of the section having thus been proceeded with, each successive lagging is connected as above described to the one preceding it and concrete placed upon it as indicated at 12 (*Fig.* 3). The lagging is then closed up on to the wall of the tunnel and secured in position, and this operation is repeated till the section is nearly complete. When nearing the roof or crown of the tunnel the roof is completed by filling in concrete from the end of the section after the lagging is in position.

This is effected by providing light metal tubes of a length corresponding to the length of the section under construction and filling them with concrete. The tubes so filled are placed in the cavity and withdrawn against the action of plungers. The concrete will thus be left in the cavity, but in order to entirely fill the space, rods of matured concrete are then driven in until the filling is complete.

In order to facilitate removal of the lagging when the concrete is set one or more of the laggings is made collapsible.

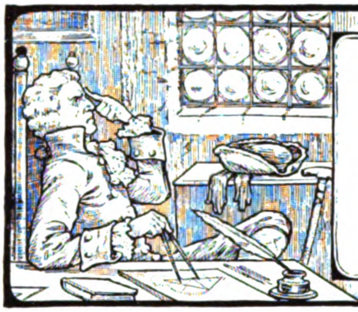
Waterproofing Cement.—No. 5,908/13. *G. T. Hill and C. G. Stone. Accepted December* 4/13.—The object of this invention is to strengthen Portland cement and render it waterproof.

The invention consists in adding magnesium silicate, in the form of soapstone, steatite, etc. The improved product, when used in the usual manner with certain proportions of sand or silica and mixed or tempered with water, forms a mortar which after setting is waterproof, and possesses tensile strength from 40 to 100 per cent. higher than mortar made from ordinary Portland cement.

The magnesium silicate, which may be added to the cement in the proportion of from 1 to 10 per cent. by weight in the form of a fine powder, must be thoroughly mixed in the cement. In order to ensure this thorough mixing, it will probably be found the most practical to add it during the process of grinding the cement clinker.

The magnesium silicate can be fed into and ground in the mill together with the cement clinker, so that its proper incorporation with the cement and also its degree of fineness may be assured.

The magnesium silicate may of course be ground to the necessary degree of fineness by other means, and then mixed in the cement in the desired proportion by hand or machine mixing.



SLENDER STRUTS.

PART II.

By H. KEMPTON DYSON.

The following article has been written by the Author to further explain the question of loads on pillars, which was touched upon by him in his articles which appeared in our journal last year on the London County Council ***Regulations*** *on Reinforced Concrete. Part I. of this article appeared in our* ***March*** *issue.—ED.*

It is frequently assumed that flat-ended struts are in the same condition as fixed-ended struts, but there may be a considerable difference. With flat ends no tensile stress can be developed at the ends, because these are merely kept in contact with the bearing surfaces by pressure. With fixed ends, on the other hand, such tensile resistance can be developed. With steel we do not need to employ different equations for the condition when the eccentricity is such as to develop tension on one side of a strut, as we do in connection with reinforced concrete, in which the concrete is not to be relied upon to act in tension; but even with steel we should note that when the eccentricity of the thrust departs from the core section of a flat ended strut the condition of the ends quickly approaches the hinged-ended condition. Up to that point, however, flat ends are as good as fixed ends, and in reinforced concrete, as this analysis only is true on the supposition that the eccentricity of thrust is never so much as to be likely to cause tension at any part of the section, we may regard flat ends as the same as fixed ends. In the case where the ends are neither flat between nor monolithic with parts of sufficient rigidity to maintain the axis at the end in the original position, the ends should not be looked upon as fixed. In practice the ends of pillars are often not so held, the beams and slabs at their ends being too flexible to give complete fixity. In such a case of imperfect fixity we might take as an approximation l_c as equal to $l/3$.

In order to distinguish how far we can go before we are likely to get tension on one side we should need to determine the core section. In the case of solid rectangular sections of one material only this is a rhombus having the principal axes as diagonals, the corners being set along each axis at one-sixth of each diameter from the centre. Consequently, if $\frac{e}{d}$ exceeds $\frac{1}{6}$ we need to look into matters closely. This, in the case of round sections, becomes a limit of $\frac{e}{d} \leqq \frac{1}{4}$. The core section may be found more exactly by setting off ordinates along the y axis, corresponding to chosen values on the x axis, according to the equation

$$y = -\frac{g_x^2}{g_y^2} \cdot \frac{x_m}{y_m} \cdot x - \frac{g_x^2}{y_m}$$

in which g_x and g_y are the radii of gyration about the axes of x and y respectively, and x_m and y_m are the maximum co-ordinates of the limiting points of zero stress—namely, those points of the section situated farthest from the centroid of the section.

There is still another condition for l_c that requires to be determined—namely, the strut having one end fixed and the other hinged but kept in its original lateral position (see *Fig.* 5).

To keep the hinged end in its position a lateral force F must be applied at the hinge, while at the fixed end there is a moment M. Then the moment at a point distant x from 0 is—

$$M_x = P_y - F(l-x)$$

and the equation of the elastic curve is—

$$EI\frac{d^2y}{dx^2} = F(l-x) - Py.$$

Integrating, we have—

$$y = A\cos x\sqrt{\frac{P}{EI}} + B\sin x\sqrt{\frac{P}{EI}} + \frac{F}{P}(l-x)$$

in which A and B are constants which can be determined by the conditions that $y=0$ when $x=0$ and $\frac{dy}{dx}=0$ when $x=0$ We find thereby

$$A = -\frac{F}{P}l$$

and

$$B = \frac{F}{P}\sqrt{\frac{EI}{P}}.$$

Substituting these values, we get—

$$y = \frac{F}{P}\left(-l\cos x\sqrt{\frac{P}{EI}} + \sqrt{\frac{EI}{P}}\sin x\sqrt{\frac{P}{EI}} + l - x\right).$$

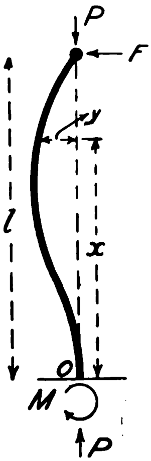


FIG. 5.

Putting $y=0$ for $x=l$, we get either $F=0$, in which case there is no bending, or

$$\tan l\sqrt{\frac{P}{EI}} = l\sqrt{\frac{P}{EI}}.$$

The angle in radians whose tangent is equal to the angle itself is 4·493 radians approximately.

Therefore

$$l\sqrt{\frac{P}{EI}} = 4\cdot493$$

and

$$P = 20\cdot187\frac{EI}{l^2}.$$

Inserting the value for y in the equation for the elastic curve, we have—

$$EI\frac{d^2y}{dx^2} = -Fl\cos x\sqrt{\frac{P}{EI}} + F\sqrt{\frac{EI}{P}}\sin x\sqrt{\frac{P}{EI}}.$$

Equating $\frac{d^2y}{dx^2}$ to zero we get—

$$\tan\frac{4\cdot493x}{l} = 4\cdot493$$

the solution of which is $x = \cdot30087l$, which means that the point of inflexion is situated $\cdot30087l$ from the fixed end and $\cdot69913l$ from the pin end, and that the value of l_c for this condition is $\cdot34956l$.

In the London County Council's second regulations for reinforced concrete the value of the virtual length v of a pillar in this condition is given as $\sqrt{2}l$, the virtual length being that of a fixed ended pillar of equivalent strength. If this were true, the value of x from the pin-end should be $\frac{\sqrt{2}}{2}l = \cdot7071l$, but as in that case x would have to equal $\cdot2929l$ the foregoing equations would not be satisfied. The L.C.C. regulations ought therefore to give the value of v as $2 \times \cdot69913l = 1\cdot4l$. approximately.

Collecting the foregoing, we have :—

Condition of Ends.	Value of l_c.
Both ends fixed	$l/4$
Both ends imperfectly fixed	say, l 3
One end fixed and one end hinged and restrained from lateral movement	$\cdot34956l$
One end fixed and one end hinged and guided into a position where the lateral movement of the free end is half the total deflection ...	$l/3$
Both ends hinged	$l/2$
One end fixed and the other end neither hinged, guided, stayed, nor supported	l

To determine all the constants in the formulæ for struts we still require to ascertain two properties of sections—namely, g/d and n/d. For the four types of pillar reinforcement shown at the top of *Fig.* 6 the following analysis applies :—

Let I = Inertia moment of area of concrete equal to that of the core of the pillar (as shaded in diagram)

I_s = Inertia moment of the steel sections.

A = area of core.

A_s = area of steel sections.

d = diameter of pillar.

r = radius of any bar about centroid.

$I_s = I_{,} I$.

$A_s = A_{,} A$.

$I/A = N_{,} d^2$.

A_v = area of one vertical bar.

δ = diameter of one round bar. $= \sqrt{\frac{4}{\pi} A_v}$

I_v = inertia moment of one vertical bar.

It does not matter whether we refer dimensions to rectangular or diagonal axes, we get for Type 1—

$$A_v = \frac{A_s}{4} = \frac{A_{,}A}{4} = \frac{A_{,}d^2}{4}$$

$$\delta = d\sqrt{\frac{A_{,}}{\pi}}$$

$$\Sigma r^2 = 4\left(\frac{d-\delta}{2}\right)^2 = d^2\left(1 - \sqrt{\frac{A_{,}}{\pi}}\right)^2$$

$$I_s = A_s \Sigma r^2 + \Sigma I_v = A_{,}d^4\left(1 - \sqrt{\frac{A_{,}}{\pi}}\right)^2 + \frac{d^4 A_{,}^2}{16\pi}$$

For Type 2—

$$A_v = \frac{A_s}{8} = \frac{A_{,}d^2}{8}$$

$$\delta = d\sqrt{\frac{A_{,}}{2\pi}}$$

$$\Sigma r^2 = 6\left(\frac{d-\delta}{2}\right)^2 = d^2 \frac{3}{2}\left(1 - \sqrt{\frac{A_{,}}{2\pi}}\right)^2$$

$$I_s = \frac{9}{8} A_{,}d^4\left(1 - \sqrt{\frac{A_{,}}{2}}\right)^2 + \frac{d^4 A_{,}^2}{32}$$

For Type 3—
$$A_v=\frac{A_s}{6}=\frac{A_{,}\pi d^2}{24}$$
$$\delta=d\sqrt{\frac{A_{,}}{6}}$$
$$\Sigma r^2=2\left(\frac{d-\delta}{2}\right)^2+4\left(\frac{1}{2}\cdot\frac{d-\delta}{2}\right)^2$$
$$=d^2\cdot\frac{3}{4}\cdot\left(1-\sqrt{\frac{A_{,}}{6}}\right)^2$$
$$I_s=A_{,}d^4\frac{3}{16}\pi\left(1-\sqrt{\frac{A_{,}}{6}}\right)^2+\frac{d^4A_{,}^2\pi}{384}.$$

For Type 4—
$$A_v=\frac{A_s}{8}=\frac{A_{,}\pi d^2}{32}$$
$$\delta=d\sqrt{\frac{A_{,}}{8}}$$
$$\Sigma r^2=2\left(\frac{d-\delta}{2}\right)^2+4\left(\frac{1}{\sqrt{2}}\cdot\frac{d-\delta}{2}\right)^2$$
$$=(d-\delta)^2=d^2\left(1-\sqrt{\frac{A_{,}}{8}}\right)^2$$
$$I_s=A_{,}d^4\frac{\pi}{4}\left(1-\sqrt{\frac{A_{,}}{8}}\right)^2+\frac{d^4A_{,}^2\pi}{512}$$

Generally $g^2=\frac{I}{A}=\frac{d^4}{12}\times\frac{1}{d^2}=\frac{d^2}{12}$ for rectangular sections,

and $g^2=\frac{I}{A}=\frac{\pi d^4}{64}\times\frac{4}{\pi d^2}=\frac{d^2}{16}$ for circular sections.

Also
$$g^2=\frac{I+(m-1)\,I_s}{A+(m-1)A}=\frac{I\,[1+(m-1)\,I_{,}]}{A\,[1+(m-1)\,A_{,}]}$$

and
$$\frac{g^2}{d^2}=\frac{N_{,}[1+(m-1)I_{,}]}{1+(m-1)\,A_{,}}$$

Inserting the foregoing values, we get :—

For **Type** 1—
$$\frac{g^2}{d^2}=\frac{\frac{1}{12}+(m-1)A_{,}\left[\left(1-\sqrt{\frac{A}{\pi}}\right)^2+\frac{A_{,}}{16\pi}\right]}{1+(m-1)A_{,}}$$

For Type 2—
$$\frac{g^2}{d^2}=\frac{\frac{1}{12}+(m-1)\frac{9}{8}A_{,}\left[\left(1-\sqrt{\frac{A_{,}}{2\pi}}\right)^2+\frac{A_{,}}{32\pi}\right]}{1+(m-1)A_{,}}$$

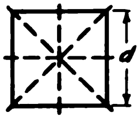
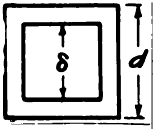
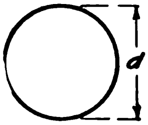
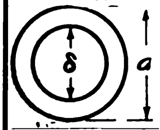
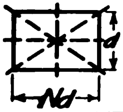
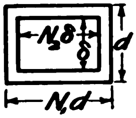
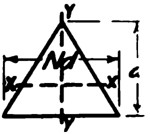
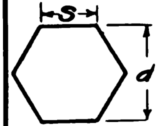
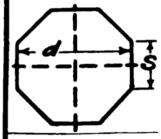
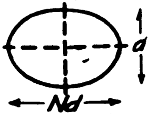
For Type 3—
$$\frac{g^2}{d^2}=\frac{\frac{1}{16}+(m-1)A_{,}\left[\frac{3}{4}\left(1-\sqrt{\frac{A_{,}}{6}}\right)^2+\frac{\pi A_{,}}{384}\right]}{1+(m-1)A_{,}}$$

For Type 4—
$$\frac{g^2}{d^2}=\frac{\frac{1}{16}+(m-1)A_{,}\left[\left(1-\sqrt{\frac{A_{,}}{8}}\right)^2+\frac{\pi A_{,}}{512}\right]}{1+(m-1)A_{,}}$$

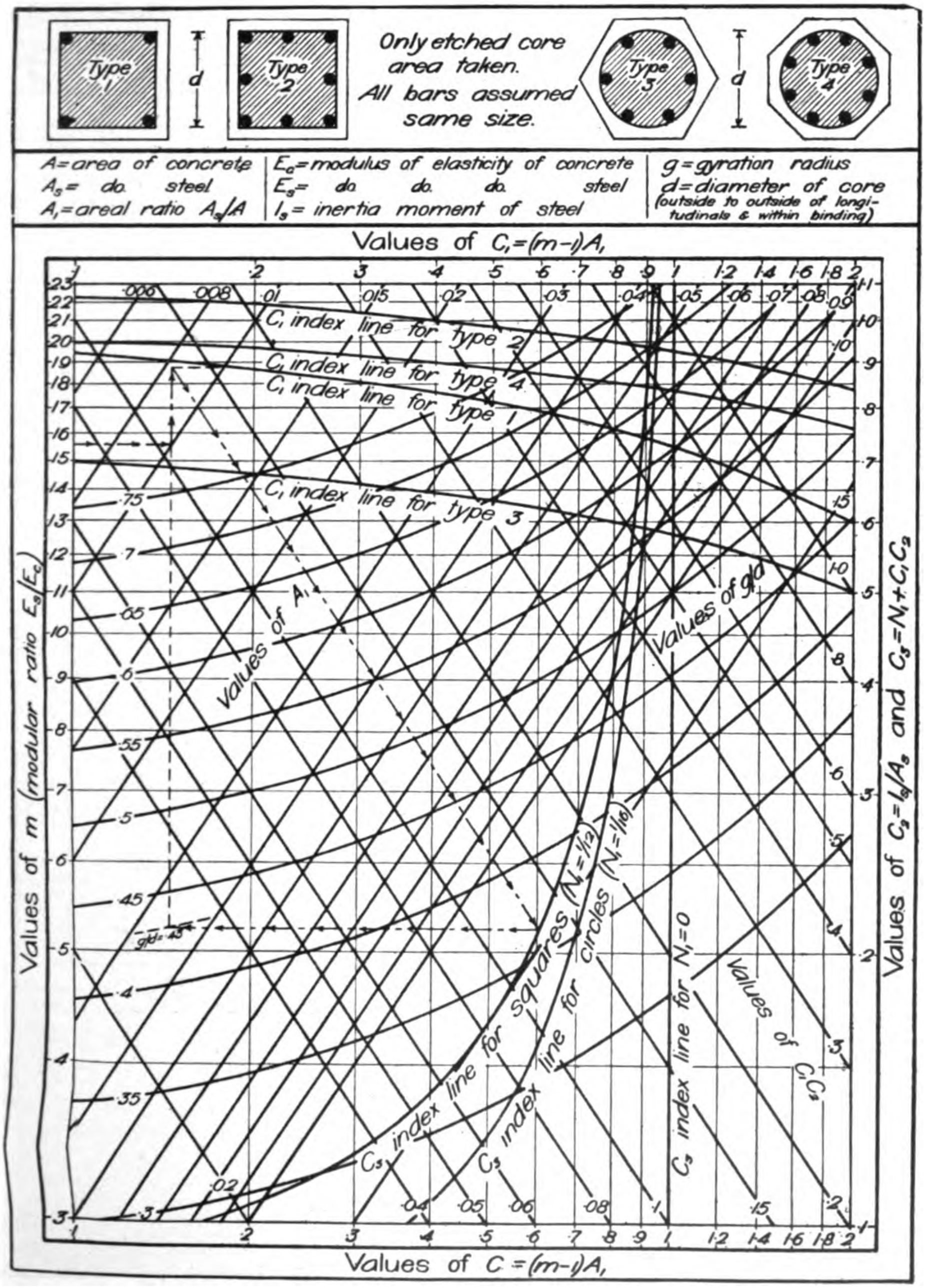
The formulæ for various values are plotted on the diagram (*Fig.* 6). The values of g/d and n/d for homogeneous sections of various shapes are given in the table on page 45.

The combination of the values of g/d, derived from *Fig.* 6, with the values of n/d for the various shapes of the four types of reinforcement is performed diagrammatically in *Fig.* 7.

We are now in a position to use *Figs.* 6, 7, and 3 to determine the resistance of slender struts of reinforced concrete. *Fig.* 3, of course, will serve for any material.

Figure.	A=Area.	I=Moment of Inertia.		g=Radius of Gyration.		n/d=Ratio of Distance between neutral axis and extreme fibre to Depth.	
		Rectangular Axes.	Diagonal Axes.	Rectangular Axes.	Diagonal Axes.	Rectangular Axes.	Diagonal Axes.
Square. 	d^2	$\frac{d^4}{12}$		$\frac{d}{\sqrt{12}}=\frac{d}{2\sqrt{3}}$		$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$
Hollow Square. 	$d^2-\delta^2$	$\frac{d^4-\delta^4}{12}$		$\frac{\sqrt{d^2+\delta^2}}{2\sqrt{3}}$		$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$
Circle. 	$\frac{\pi d^2}{4}$	$\frac{\pi d^4}{64}$		$\frac{d}{4}$		$\frac{1}{2}$	
Hollow Circle. 	$\frac{\pi}{4}(d^2-\delta^2)$	$\frac{\pi}{64}(d^4-\delta^4)$		$\frac{\sqrt{d^2+\delta^2}}{4}$		$\frac{1}{2}$	
Rectangle. 	Nd^2	Max. $\frac{N^3d^4}{12}$ Min. $\frac{Nd^4}{12}$	$\frac{N^3d^2}{6(N^2+1)}$	Max. $\frac{Nd}{2\sqrt{3}}$ Min. $\frac{d}{2\sqrt{3}}$	$\frac{Nd}{\sqrt{6(N^2+1)}}$	Max. $\frac{N}{2}$ Min. $\frac{1}{2}$	$\frac{N}{\sqrt{N^2+1}}$
Hollow Rectangle. 	$N_1d^2-N_2\delta^2$	Max. $\frac{N_1^3d^4-N_2\delta^4}{12}$ Min. $\frac{N_1d^4-N_2\delta^4}{12}$	$\frac{N_1^3d^2}{6(N_1^2+1)}$ $\frac{N_2^3\delta^2}{6(N_2^2+1)}$	Max. $\sqrt{\frac{N_1^3d^4-N_2^3\delta^4}{12(N_1d^2-N_2\delta^2)}}$ Min. $\sqrt{\frac{N_1d^4-N_2\delta^4}{12(N_1d^2-N_2\delta^2)}}$	$\left[\left(\frac{N_1^3d^2}{N_1^2+1}-\frac{N_2^3\delta^2}{N_2^2+1}\right)\div 6(N_1d^2-N_2\delta^2)\right]^{\frac{1}{2}}$	Max. $\frac{N_1}{2}$ Min. $\frac{1}{2}$	$\frac{N_1}{\sqrt{N_1^2+1}}$
Isosceles Triangle. 	$\frac{Nd^2}{2}$	About xx $\frac{Nd^4}{36}$	About yy $\frac{N^3d^4}{48}$	About xx $\frac{d}{3\sqrt{2}}$	About yy $\frac{Nd}{2\sqrt{6}}$	About xx Max. $\frac{2}{3}$ Min. $\frac{1}{3}$	About yy N
Hexagon. 	$\frac{3\sqrt{3}}{2}S^2$	$\frac{5\sqrt{3}}{16}S^4$		$\frac{d}{6}\sqrt{\frac{5}{2}}=\cdot 2635d$ or $\frac{S}{2}\sqrt{\frac{5}{6}}=\cdot 456S$		$\frac{1}{2}$	$\frac{S}{d}=\frac{1}{\sqrt{3}}=$ $=\cdot 5773$
Octagon. 	$2(\sqrt{2}+1)S^2$	$\frac{8\sqrt{2}+11}{12}S^4$		$\frac{d}{2}\left(\frac{3-\sqrt{2}}{6}\right)^{\frac{1}{2}}=\cdot 257d$ or $\frac{1}{2}\left(\frac{5+3\sqrt{2}}{6}\right)^{\frac{1}{2}}S=\cdot 62056S$		$\frac{1}{2}$	$\frac{1}{(2+\sqrt{2})^{\frac{1}{2}}}$ $=\cdot 541$
Ellipse. 	$\frac{\pi Nd^2}{4}$	About major axis $\frac{\pi Nd^4}{64}$	About minor axis $\frac{\pi N^3d_4}{64}$	About major axis $\frac{d}{4}$	About minor axis $\frac{Nd}{4}$	About major axis $\frac{1}{2}$	About minor axis $\frac{N}{2}$

The immediate purpose of this article is to correct the values for calculating the strength of struts put forward in the L.C.C. Regulations for Reinforced Concrete Buildings in London.



[*Copyright of H. Kempton Dyson.*]

FIG. 6.

Let us take first the most adverse case, and see how the L.C.C. regulations compare with Alexander's and the Gordon-Rankine formula—namely, a pillar of type 2 able to bend about its transverse axis, and reinforced with 1 per cent. of vertical steel bars, and constructed of concrete proportioned 1 cement, 2 sand, 4 coarse material, whose ultimate strength, as ascertained by tests on cubes cast in moulds and made with the material as used on the job, is not less than 2,000 lbs./in^2, though the average strength as realised on cubes cut out of the work would be over 2,400 lbs./in^2. This becomes further justified by considerations of eccentric loading in conjunction with variation in the modulus of elasticity of concrete as the stress increases.

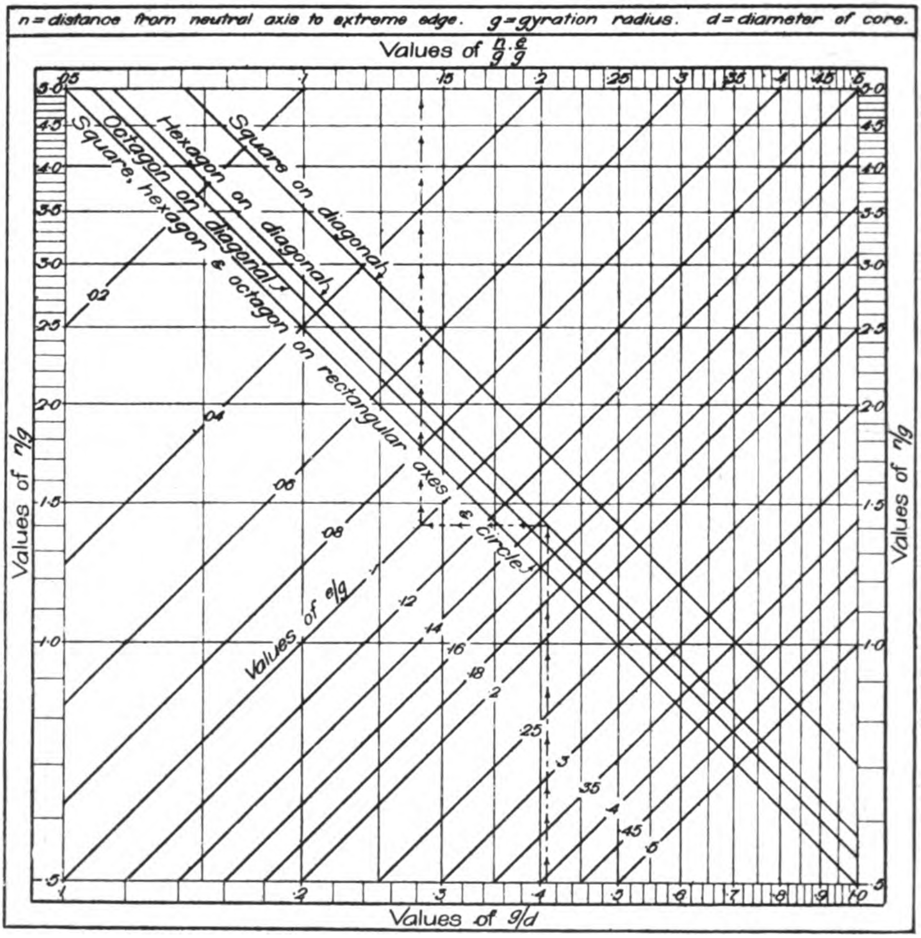


FIG. 7. [*Copyright of H. Kempton Dyson.*]

$$\text{Then } E_c = 600\ u_c = 1{,}440{,}000 \text{ and } m = \frac{50{,}000}{u_c} = \frac{50{,}000}{2{,}400} = 21.$$

Travelling from the value 21 in the left-hand margin of *Fig.* 6 until the line for value of $A_{,,}$ marked ·01, is met, next vertically upwards to the conjunction of a horizontal trace from the intersection of the $A_{,}$ line marked ·01 and the "C_1 index line for type 2," the parallel to the lines for values of C_1 C_2 until we meet the "C_2 index line for squares," now outwards horizontally to meet the vertical trace from the very first intercept derived, we find $g/d = \cdot 49$. The process is shown by the guiding arrow lines.

Now, going to *Fig.* 7, we find the value of $g/d = \cdot 49$ in the bottom margin, travel vertically upwards until the line is met marked "Square on diagonal," next horizontally to meet the value of e/g, and then vertically upwards to the top marginal scale, we derive the value of $\frac{n}{g} \cdot \frac{e}{g}$. The process is again shown by guiding arrow lines.

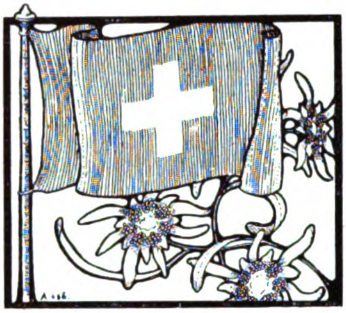
Finally, going to *Fig.* 3, we obtain the following values for a fairly long column of 20 ft. in height, which, because it is imperfectly fixed, will have a value of $l_c = 20 \times 12 \div 3$, so that $e = \cdot 01\ l_c = \cdot 01 \times 20 \times 12 \div 3 = 0{\cdot}8$ inch :—

VALUES OF QUALIFIER Q FOR IMPERFECTLY FIXED ENDS.

For a Slenderness Ratio of l/i =	12	14	16	18	20	22	24	26	28	30
or l_c/g =	8·2	9·5	10·9	12·2	13·6	15	16·3	17·7	19	20·4
Value of e/g =	·1	·1	·109	·122	·136	·15	·163	·177	·19	·204
L.C.C. Regulations	·833	·625	·458	·375	·292	·25	·208	—	—	—
Rankine	·876	·856	·84	·825	·81	·795	·78	·76	·75	·74
Alexander	·9	·895	·877	·86	·842	·822	·8	·8	·759	·738

It is necessary to explain that in the foregoing table the values given for the L.C.C. Regulations are derived from the actual ones therein contained by multiplying by ·833, because the working stress in direct compression is 500 lbs./in^2, whereas the stress in beams is put at 600 lbs./in^2, the stress thus being reduced to $\frac{5}{6} = \cdot 833$ times the ordinary permissible stress.

We see from this that on any basis the values in the Regulations are too extreme for exceptional cases. On the other hand, in struts which are hinged at one or both ends, or are fixed at one end, and which are long though bulky and consequently not very slender, the accidental eccentricity created in construction might be so great as to render the L.C.C. values unsafe. Therefore the author thinks it would be much better to give a table well on the safe side for pillars imperfectly fixed at both ends, so as to be simple enough for ordinary uses, but to permit engineers as an alternative to calculate the struts by a formula of the Alexander type with the particular constants aforesaid.



REINFORCED CONCRETE VIADUCT, LANGWIES, SWITZERLAND.

By H. SCHUERCH, Chief Engineer of Messrs. Ed. Zueblin & Cie, Strassburg i. Alsace.

The following is a free Translation taken from an article which appeared in our contemporary, "Armierter Beton," and which we publish by the courtesy of that journal. The illustrations were placed at our disposal by Mr. Schuerch, and our translation has been prepared by Mr. C. Wesemann, Civil Engineer.—ED.

THE viaduct here described is being constructed on the route of the new Chur-Arosa meter gauge electric railway, Switzerland, close to the village of Langwies, and is necessary for carrying the permanent way across the valley of Plessur and Sapuenerbach, where two streams come together on the site, and where when the snow melts these mountain brooks often carry down enormous quantities of water and pebbles, for which a free passage is desirable.

The lack of suitable building material and the difficulty of bringing heavy steel work on to the site, owing to the bad condition of the roads, as well as the existence of good gravel and sand material on the spot, led to the use of reinforced concrete for the construction of the viaduct.

Objections were raised in the first instance by the Swiss Railway Department (to whom the designs had to be submitted for approval) to the use of reinforced concrete for a structure of such magnitude. Finally, however, the contracting firm, Messrs. Ed. Zueblin & Cie, of Strassburg, who had been at great pains in the preparation of the design, and had worked out the static calculations most carefully, succeeded in obtaining the necessary consent to the use of reinforced concrete, the tender being supported by ample guarantees.

The bridge crosses the valley with one main arch of 96 m. clear span between the abutments, *i.e.*, 100 m. span from centre to centre of the springers (*Fig.* 1). The theoretical rise between centre springer and centre crown of the arch is 42 m. On either side of the main arch are a series of four smaller openings, each having a clear span of 14·7 m. Beyond the end abutments three more openings were afterwards added, on the side towards Langwies, instead of an earth embankment, proposed in the first place. Two of these additional openings have a clear span of 13 m., and the remaining one has a clear span of 10 m. The nature of the subsoil admitted of the central section of the viaduct being constructed in form of an elastic or non-hinged arch, whereas the deck of the outer spans was designed with continuous girders, as the great elevation of the roadway platform above ground necessitated a structure without horizontal thrust, the high and slender pillars being sufficiently elastic to admit of the dilatation of the railroad slab. In addition to this the latter is separated by means of expansion joints at the top of the supporting double pillars. Owing to its high altitude (1,320 m. above sea-level), the viaduct is exposed to great changes of temperature, and therefore the question of expansion and contraction had to be carefully taken into consideration.

The central span comprises two separate arched rings, the thickness of

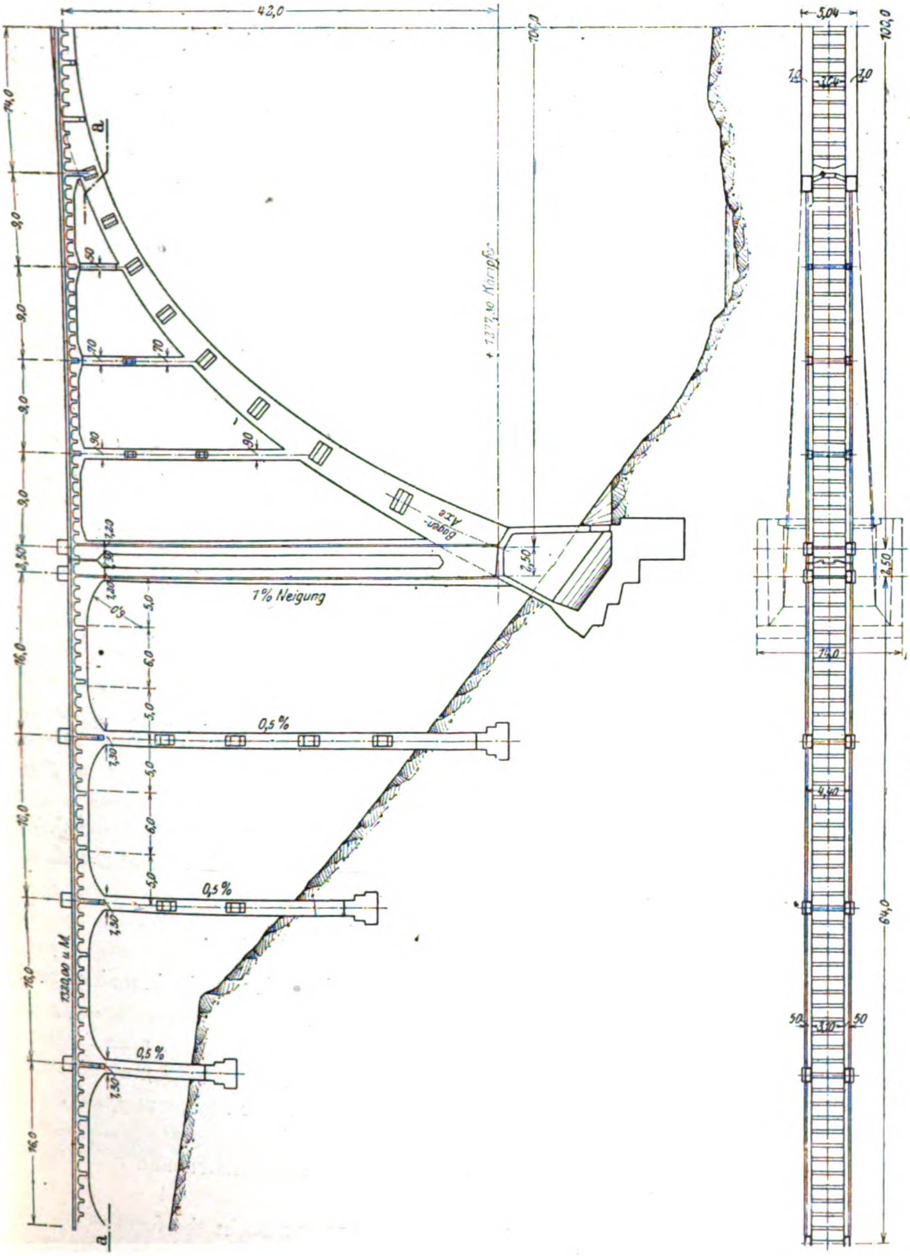


Fig. 1. Longitudinal Section and Plan.
Reinforced Concrete Viaduct, Langwies, Switzerland.

which is 2·10 m. at the crown. The width of either rib at the top of the crown is 1·00 m., and, being battered lengthwise, it increases regularly from crown to springer. The two arched rings are tied together by means of rigid cross-beams.

With the view of ensuring greater stability, the whole of the viaduct (including the skeleton pillars) is battered upwards (*Fig.* 9).

The roadway is 4 m. wide between the parapets. This dimension includes 0·70 m. for either side-walk. The railroad consists of a 30 c.m. ballast-bed, which is underlaid by a layer of sand, resting upon the insulated cement floor of the railroad slab. The latter stretches between transverse girders, of which those at the top of the pillars have a greater depth in order to obtain an increased rigidity in the transverse direction of the slab.

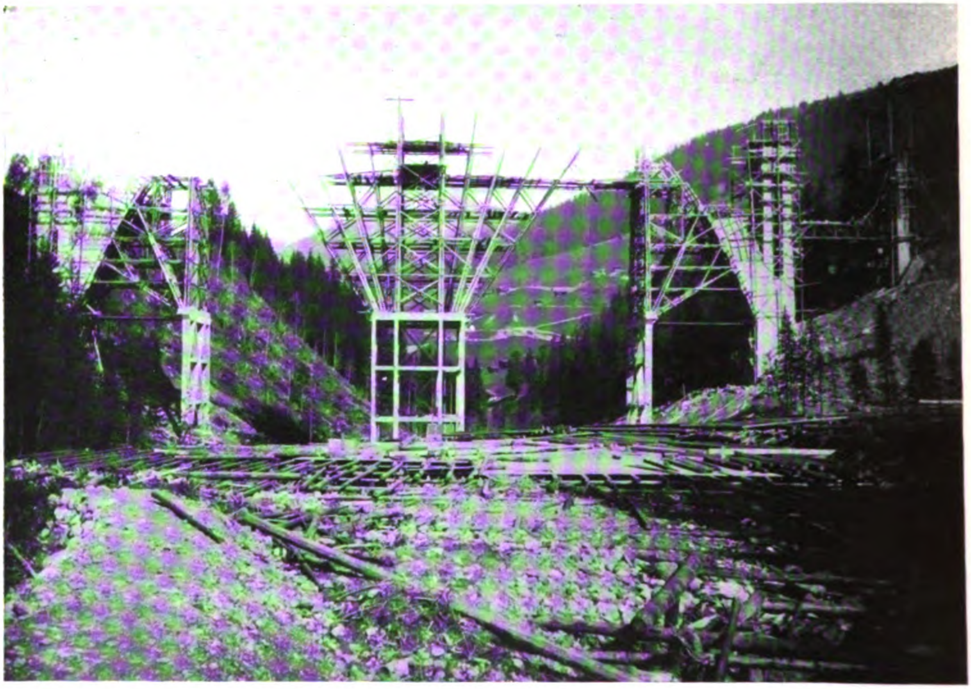


Fig. 2. View of Arch Centreing in Early Stages of Construction.
REINFORCED CONCRETE VIADUCT, LANGWIES, SWITZERLAND.

The longitudinal girders of the superstructure of the central arch are continuous beams running throughout the four spans, and are connected at the crown with the arch itself and above the springers with the abutment pylons. As the connection with the crown of the arch does not allow of any movement, the pillars had to be sufficiently elastic to allow for the expansion and contraction of longitudinal deck-girders.

The main girders of the outer spans are constructed in the form of beams with a varying moment of inertia (*Fig.* 7). They also run continuously over four spans, and are connected with their supports in such a manner that a certain amount of movement is possible. The bearing plates at the points of support of the pillars of the outer spans have been reduced to a narrow margin

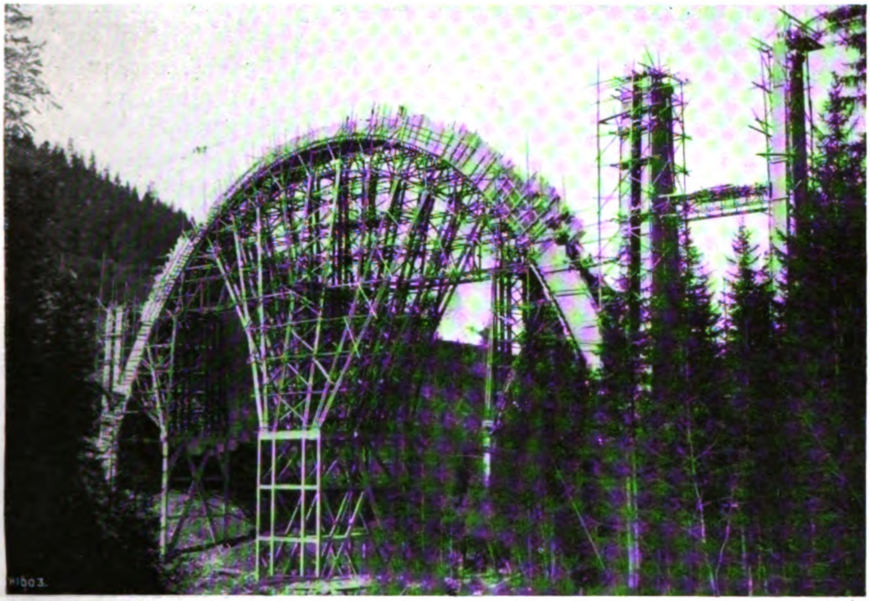


Fig 3 View of Arch Centreing, showing part of finished Concrete Work.

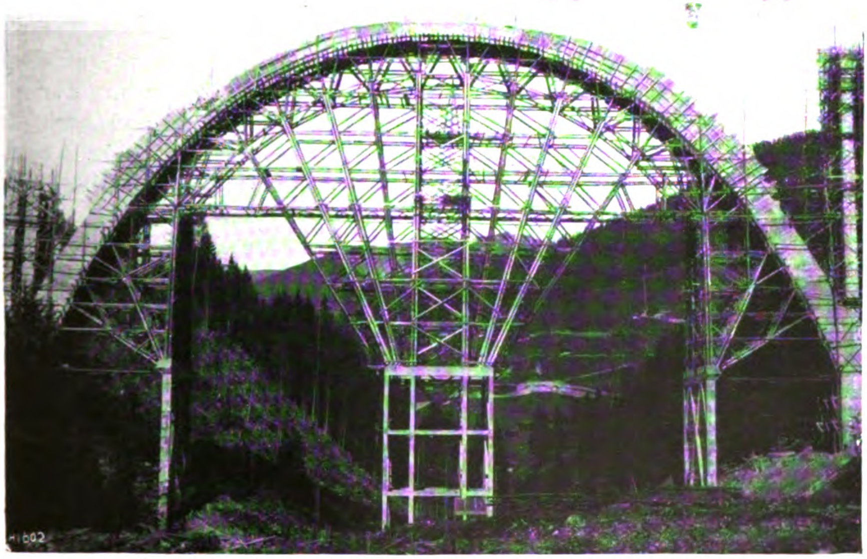


Fig. 4. Front View of finished Arch Centreing showing Cable Ropeway.
Reinforced Concrete Viaduct, Langwies, Switzerland.

of area, with the view of ensuring a hinge effect. Regarding the pillars themselves, they are constructed in the form of skeleton pillars (*Figs.* 6 and 9), viz.,

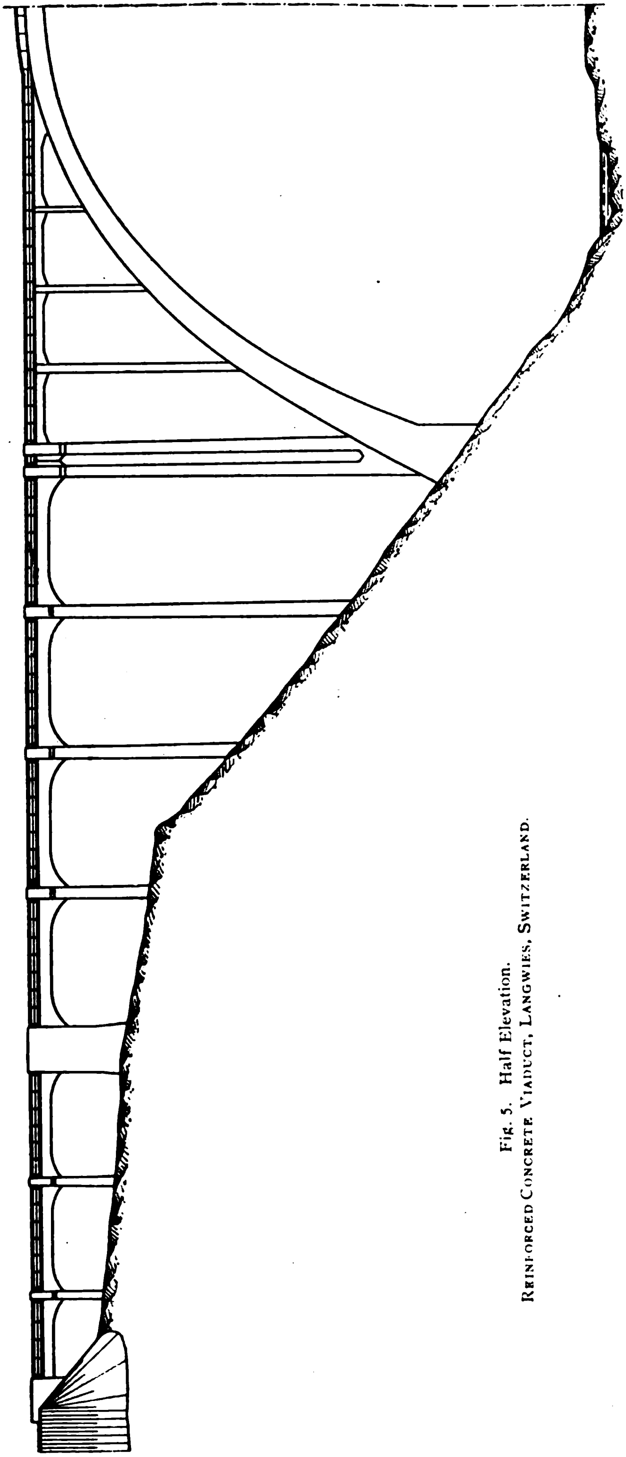


Fig. 5. Half Elevation.
Reinforced Concrete Viaduct, Langwies, Switzerland.

two cross-tied uprights, as the wind forces are carried along the roadway slab direct to the respective abutments and to the huge double pylons on the other side. The latter, therefore, instead of being cross-tied by single transverse beams, are braced together by means of a solid cross-spandrel wall (*Fig.* 6). The inner pair of uprights is connected with the roadway slab of the central span, the outer pair with the roadway slab of the approach openings, in order to allow either section of the viaduct to expand or contract independently.

The construction of the viaduct has been designed from the point of view of ensuring a maximum saving of material and a minimum as regards actual stresses. This was rendered more possible owing to the live load on the bridge being a comparatively light one in proportion to its dead weight. This also explains the application of two cross-tied arched ribs instead of a monolithic ring, although the latter form has also been carefully taken into consideration. The static calculation of the viaduct has been based on the assumption of a test-load train that comprises two locomotives of 65 tons service weight each (the type of the Rhaetic Railways), and an unlimited number of adjoining goods trucks that are coupled in one direction. With regard to the static calculation of the secondary girders—*viz.*, the railroad deck and the minor spans—an addition to the above live load of 15 per cent. has been considered. The additional forces that have been taken into account comprise :—

(1) A temperature change of ± 15 deg. (Celsius);

(2) Contraction due to setting — 20 deg.

(3) Braking forces—one-seventh of the total weight of the loading train-axles.

(4) Wind pressure :

(*a*) 100 kg/m², when the bridge is in superloaded condition;

(*b*) 150 kg/m², when the bridge is in unloaded condition.

The modulus of elasticity has been assumed :

$$E = 2,000,000 \ \text{t/m}^2.$$

The proportion : $\dfrac{E \text{ steel}}{E \text{ concrete}} = 15.$

The safe maximal compressive stress of concrete :

$$\sigma = 35 \ \text{kg/cm}^2,$$

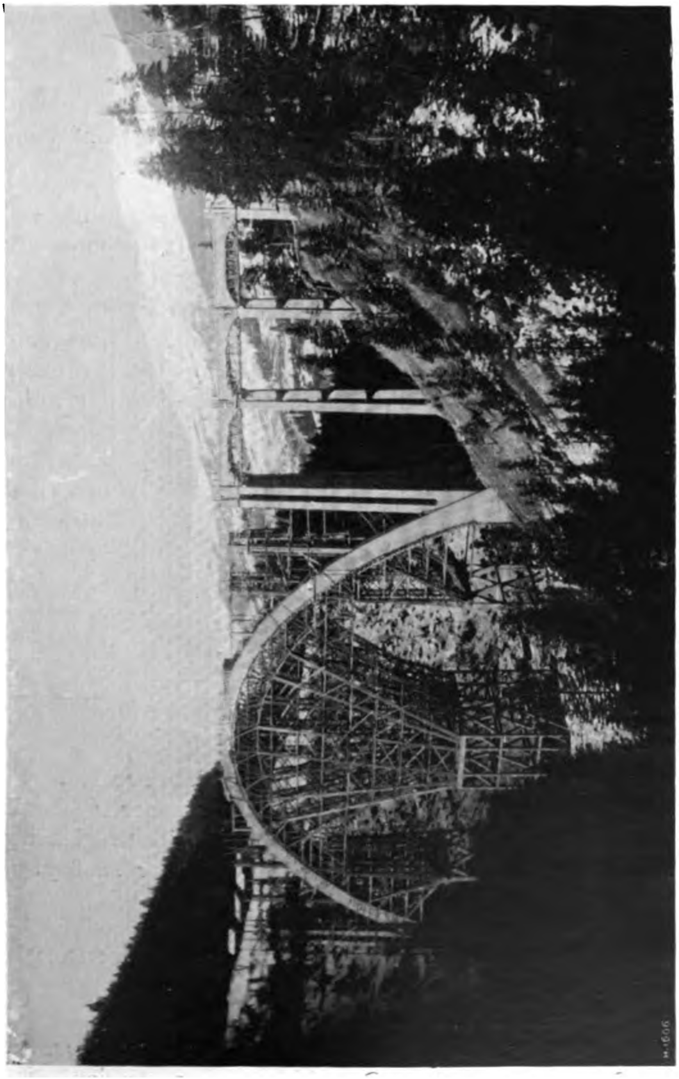


Fig. 6. The Main Arch completed and the openings toward Langwies.
REINFORCED CONCRETE VIADUCT, LANGWIES, SWITZERLAND.

providing the dead weight of the bridge is combined with the most unfavourable superload (live load);

$$\sigma = 45 \text{ kg/cm},$$

providing all the secondary and additional forces are taken into account, *i.e.*, temperature, contracting due to setting, braking-forces and wind-pressure.

The safe shearing stress of concrete is assumed:

$$\tau = 4 \text{ kg/cm}^2.$$

Safe tensile stress of steel for reinforcement:

$$= 1{,}000 \text{ kg/cm}^2,$$

provided the dead weight of the bridge is combined with the most unfavourable superload (live load);

$$\sigma = 1{,}200 \text{ kg/cm}^2,$$

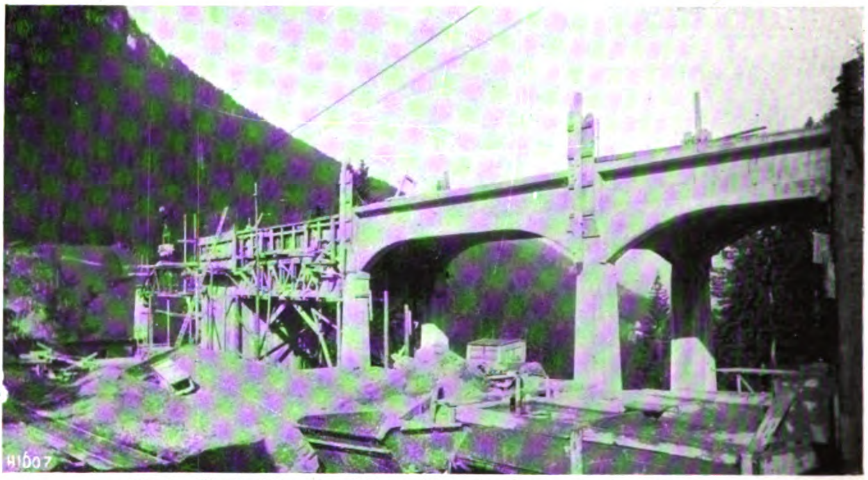


Fig. 7. Finished Beams and Centreing to Openings on the Langwies Side.
Reinforced Concrete Viaduct, Langwies, Switzerland.

provided all the secondary and additional forces are taken into account.

The above figures are based upon the assumption that the concrete (that is mixed on the spot and is daily controlled and tested by a Martens' set registering apparatus) shows the following minimum standard strength after 28 days of setting-time:

$$180 \text{ kg/cm}^2,$$

when being rammed on the spot in a plastic condition (poured concrete);

$$250 \text{ kg/cm}^2,$$

when being rammed on the spot in a moist condition.

The Ritter method was employed in the calculations of the internal stresses in all those parts of the construction that are subject to compression—*viz.*, the central arch and the pillars—and also for the determination of the tensile bending stress of the concrete construction, whereas the Christophe method was adopted in calculating the internal stresses of all the other parts of the structure—namely, those parts that are subject to bending forces and for the calculation of the reinforcement. The shearing forces were very carefully determined, and steel rods in the form of stirrups are provided wherever they exceed the safe shearing stress of concrete—*viz.*:

$$\tau = 4 \text{ kg/cm}^2.$$

The resistance against collapsing was calculated according to the Ritter method.

The peculiar arch-centreing (*Figs.* 2, 3 and 4) is well worth special mention. The upper part of the falsework has been constructed in the form of a fan built up with round timber obtainable on the spot in great lengths, at a low price and of good quality. This timber scaffolding is supported by three reinforced concrete towers which have been constructed in the form of framework or skeleton towers. The reason for these reinforced concrete towers was due to the following causes. It was not advisable to obstruct the valley too much by the falsework, as the scaffolding is exposed to danger from floods, and is thus liable to damage at times when the snow melts and the two mountain brooks, which join just on the building site, carry down enormous masses of water and pebbles. For this very reason the erection of a scaffolding composed of uprights was out of the question, and the tower system only was suitable (*Fig.* 8). Timber-work towers would have obstructed the passage more than reinforced concrete towers, and furthermore they would not have possessed the same amount of stability. The substructure and the foundations would in any case have required the use of reinforced concrete even if timber-work towers had been erected, as the driving of wooden piles was absolutely impossible on account of the nature of the subsoil, which is composed of coarse pebbles and is intermixed with loose blocks.

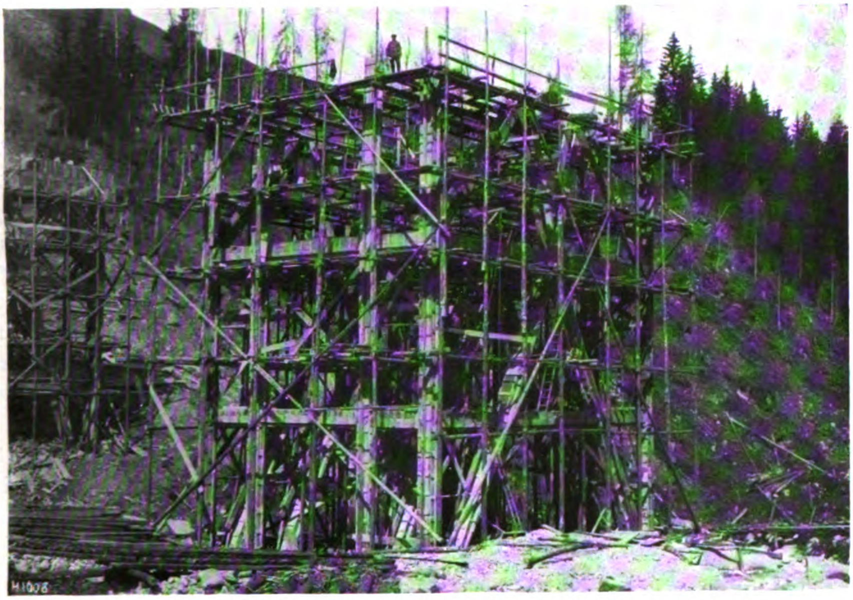


Fig. 8. Reinforced Concrete Towers in course of construction.
REINFORCED CONCRETE VIADUCT, LANGWIES, SWITZERLAND.

The total settlement of the main arch had to be reduced to a minimum, and this also was another reason for using reinforced concrete for these towers. When the central arch was closed the arch centreing showed a total settlement of, roughly, 30 mm., inclusive of 10 mm. which occurred through the head-pieces of the diagonal struts cutting into the capping-pieces of the stringers.

The erection of the viaduct was begun late in 1912, but at the commencement of the work operations had to be confined to foundations of the abutments, winter setting in before time and causing an interruption of the work for several months. Not before April, 1913, could the work be resumed. Bad weather during the early summer delayed progress once more, and especially protracted the completion of the falsework of the central arch. Later on, however, the weather changed for the better, and by the combined efforts of all those concerned in the work, it was finally rendered possible to complete the arch-centreing for the most part on September 6th and the concrete work of the large arch—excepting for the closing of some joints—on October 6th in 1913. The last of those joints, which were kept open intentionally for a long time, was closed on October 27th.

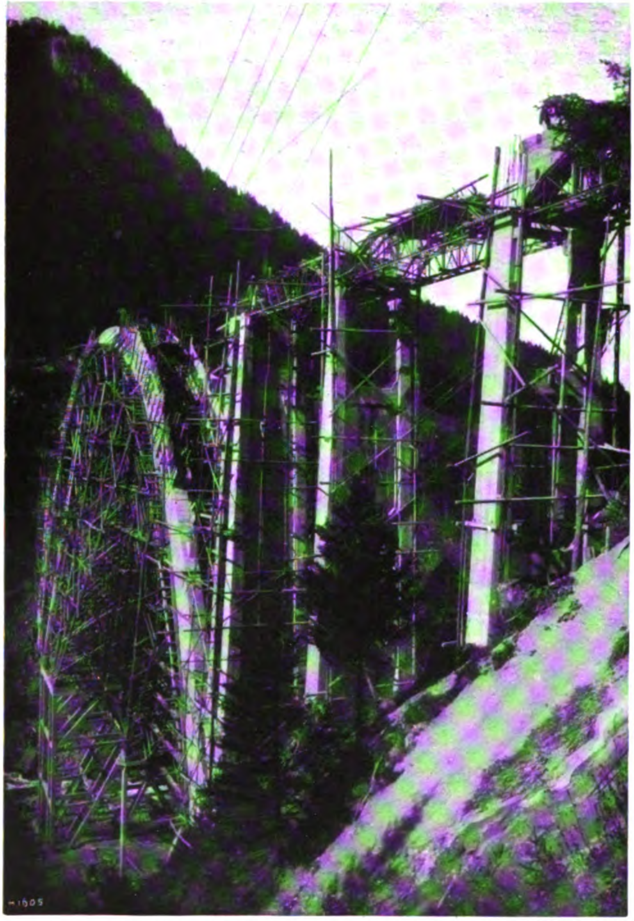


Fig. 9. Side View of Arch Centreing in course of erection, and side openings toward Langwies.
REINFORCED CONCRETE VIADUCT, LANGWIES, SWITZERLAND.

The winter, of course, has again interrupted the work. But still, the approach openings on the side toward Langwies are now completed (*Fig.* 7); so is the main arch and the whole of the pillars of the superstructure above the central section (*see Frontispiece*). The pillars of the outer spans on the side toward Arosa are partly finished. There remains to be completed this spring the roadway platform above the central span and above the approach openings on the side toward Arosa.

The building of this viaduct has called forth a series of rather ample investigations and tests as to the strength of concrete, steel and timber, including tests on the elastic properties of concrete.

CALCULATIONS AND DETAILS FOR STEEL-FRAME BUILDINGS FROM THE DRAUGHTSMAN'S STANDPOINT.

By W. CYRIL COCKING, M.C.I.

In view of the importance and great value of this Paper, which was read before the Concrete Institute, we are giving an abstract of same as a principal article rather than under our heading "Recent Views." There were numerous tables at the end of the Paper which are of remarkable excellence, and which were referred to in the discussion but which we have not been able to reproduce here. Only a short resumé of the discussion is also given. The Institute is to be congratulated upon this Paper.—ED.

THE draughtsman's point of view in the methods of calculation and preparation of details for modern steel-frame buildings is a most important one and is seldom considered.

In order to give the draughtsman a fair start it is necessary that certain matters should be agreed upon between the architect or his deputy and the district surveyor before the architect's plans are sent out for competitive tenders from constructional firms.

The district surveyor should be consulted at the very commencement of every job regarding which he may have any discretionary powers. The matters to be so discussed and agreed are chiefly the following :—

PARTICULARS OF LOADING, ETC., TO BE AGREED WITH THE DISTRICT SURVEYOR.

1. *Dead and Superloads.*—All firms competing should be provided by the architect with the fullest possible details and particulars of floor construction, roof coverings, ceilings, casings to beams and pillars, partitions, the proportion of masonry in external walls—such as heavy cornices and ashlar work—and all special loading, such as lift gearing, water-tanks, heavy safes, travelling cranes or runways, etc.

2. *Foundations.*—The maximum pressures allowed upon the soil; the fullest possible information should be given for the design of party-wall foundations; depths and extreme limit of spread for foundations to party-wall pillars.

3. *Eccentric Loading.*—The District Surveyor's requirements for the treatment of eccentric loading on pillars.

4. *Pillar End Fixing.*—The District Surveyor's decisions as to what shall constitute a fixed or hinged end for the purposes of preparing the pillar calculations.

5. *Form of Calculations.*—The form in which the District Surveyor requires the calculations and detailed drawings to be prepared for submission to him for his approval.

Provided the above information is given to all the competing firms the competition would be a fair one, and it is open to engineering firms to combine together and insist upon the receipt of such information before agreeing to tender.

Other considerations which should be impressed upon architects in general when agreeing to tender are, firstly, that the engineer should be allowed a reasonable time in which to prepare his scheme and tender; and secondly that, should he be successful in securing the contract, he should have at least two to four weeks' start in advance of the builder or general contractor in order to prepare his working drawings and settle the exact positions of the pillars, foundations, etc., and the fabrication of the steelwork required for the first deliveries.

In the past it was the practice to consider the loading on a floor as inclusive—that is, the load per square foot upon which the calculations were based was assumed to include the weight of construction; now, however, it is becoming the practice to ascertain individually the superloads, dead weights of floors, beams, pillars, beam and pillar-casings, etc. This is certainly a distinct improvement, and tends towards greater accuracy and economy in design.

SUBJECTS FOR DISCUSSION.

Eccentric Loading.—What is the effect of eccentric loading? This interesting and important question is not so easily answered as one would suppose from a casual consideration.

Take the case of a pillar composed of a 10 in. × 5 in. **I** at 30 lb. and 2-8 in. × ⅜ in. plates, and which is considered as possessing one end fixed and the other end hinged, and is capable of supporting a central load of 53·4 tons on a laterally unsupported length of 11 ft., according to the stresses allowed by the Act.

Assuming that the stresses allowed by the Act bear a factor of safety of 4, the central load causing failure would be equal to 213·6 tons.

Now let us consider the load of 19·95 tons applied to the web of pillar as being an eccentric load, the connection being made with a well-stiffened seating rivetted to the web of the pillar. The seating or bracket being stiffened, the load would undoubtedly be considered by the eccentricity devotee as acting on the extreme edge of the seating angle.

Assume that this angle for the case under consideration as being an 8 in. × 4 in. × ⅝ in. angle.

The eccentric arm would therefore be 4 in. + 0·18 in., equals 4·18 in.

Now the eccentricity coefficient from the formula usually adopted, *i.e.*, $C_e = 1 + \frac{en}{g^2}$, is equal to—

$$1 + \frac{4{\cdot}18 \times 4}{1{\cdot}75^2} = 6{\cdot}46,$$

therefore the additional equivalent central load to that already included on the Pillar Sheet is equal to—

$$19{\cdot}95(6{\cdot}46 - 1{\cdot}25) = 103{\cdot}9 \text{ tons},$$

giving a total equivalent central load of—

$$103{\cdot}9 + 48{\cdot}4^T = 152{\cdot}3 \text{ tons},$$

the maximum fibre stress being—

$$\frac{152{\cdot}3}{14{\cdot}82} = 10{\cdot}28 \text{ tons/in.}^2.$$

also the factor of safety being—

$$\frac{213{\cdot}6}{152{\cdot}3} = 1{\cdot}4.$$

Further, the actual stresses induced in the pillar will depend to a large extent upon the depth and deflection of the beam, the width and moment of inertia of the pillar, and the rigidity of the connection of the beams to the pillar, also chiefly upon the continuity of the pillar at the level of the beam connections—factors which the before-mentioned formula conspicuously ignores.

As soon as we make the pillar continuous or securely fix the ends the stresses are entirely altered in their distribution, and the effects of the eccentricity vary from one to one-half those computed by the usual formula according to the amount of continuity and fixture at the ends.

The question may be considered very simply in the following manner: Take, for example, a pillar supporting a cantilever in the manner shown in *Fig.* 1. In its deflected form such a pillar would indicate a reversal of bending moment at the connection of the cantilever to the pillar, the lower pillar curving out to the left and the upper pillar curving out to the right clearly indicating that the stresses due to eccentricity are distributed both above and below the point of connection, and not below only as generally assumed. The sum of the eccentric stresses in A and B is approximately equal to $W\frac{e}{d}$, and the sum of the total stresses C and D is equal to $W\left(\frac{e}{d}-1\right)$. The pillar being continuous the stresses would be distributed half above and half below the connection, therefore the total eccentric stress in A in tension and in B in compression would be equal to $\frac{We}{2d}$, and similarly the stresses in C in compression and in D in tension would be equal to $\frac{W}{2}\left(\frac{e}{d}-1\right)$, or the total stresses, and similarly the maximum stresses per square inch, are about one-half those computed in the usual way by the formula—

$$\frac{W}{A}\left\{1+\frac{\left(e-\frac{d}{2}\right)d}{2g^2}\right\}=\frac{W}{A}\left(1+\frac{en}{g^2}\right)$$

Arm of Eccentricity.—Some engineers hold the opinion that the eccentric load on a pillar acts at the centre of area of the seating through which the load is transmitted—that is, at point A on *Fig.* 2. Again, others contend that the eccentric load can be assumed as acting in the plane of the external face of the seating—that is, at point B on *Fig.* 2. Yet again other engineers assume that the eccentric load acts in the plane of connection of the seating to the pillar, point C on *Fig.* 2.

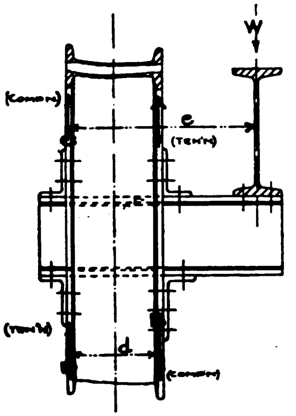


FIG. 1.

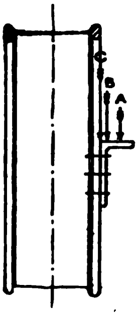


FIG. 2.

End Fixing of Pillars.—Another difficult point regarding which the draughtsman must exercise his knowledge and experience is the question of "end fixing" to pillars. What constitutes a fixed end? What can be termed a hinged end? Also what relation does a flat end bear to either or both of the above?

The opinion is generally held that the topmost connection of a pillar in the topmost storey and the lower connection of a pillar in the bottom storey shall be considered as hinged ends, though the latter connection or base of the pillar could reasonably be considered as a "flat" end.

Also it seems reasonable to assume that the pillars in external walls which only receive two- or three-way connections shall be considered as having one end hinged and the other fixed.

The important question remains, When can a pillar be assumed to possess both ends fixed?

Where a pillar is continuous both above and below the connection at two consecutive floors, and receives at both floor connections or "ends" a four-way connection in which the heavier or deeper beams are connected to the pillar perpendicular to its weaker axis, such a pillar shall be considered as having both ends fixed.

These three important questions—eccentric loading, eccentric arm, and the end fixing of pillars—should seriously be considered by the Institute, and the District Surveyors' Association should be approached with the object of arriving at practical solutions of these problems.

* * * * *

After a most valuable chapter on Calculations, which it is impossible to deal with in summary owing to the references to the illustrations and diagrams, most of which are omitted, the author went on to deal with the following questions:—

Deflection.—The question of deflection is not one that need cause us any grave concern, for Section 22, Clause 7 of the Act clearly indicates that the question of deflection can be ignored, except in cases where the ratio of span to depth of beam is greater than 24. When this ratio is exceeded the calculation of the deflection must be made in order to ensure that the maximum deflection shall not exceed $\frac{1}{400}$th part of the span.

When it is required to use shallow beams the flange stress must be reduced in order not to exceed the permissible deflection.

For plate girders, compound girders, and lattice girders in which the modulus of the cross-section is proportioned to the bending moment at various points along the span, the depth being constant, we may consider such beams as beams of uniform strength for the purposes of calculating the deflection.

Seeing that the greatest deflection for a beam of uniform section is obtained with a uniformly distributed load, it is quite sufficient for all practical purposes to treat a beam which has to support a complex system of loading as if it were loaded with the equivalent uniformly distributed load.

Shear.—The maximum vertical shearing values for webs can be ascertained from the following formula—

$$s=5\cdot5td,$$

where s = maximum vertical shearing value for web in tons,
t = thickness of web in inches,
d = total depth of web or **I** beam in inches.

The depth of an unstiffened web must not exceed sixty times the thickness of web. This is a very liberal ratio, and should be reduced somewhat for very thin webs.

The question of rivets acting in double shear is one that is apt sometimes to be overlooked, especially when designing pillars and beams where web connections are made on both sides of the beam. The bearing values for the rivets through the webs of pillars and beams should always be inquired into, especially when using the lighter sections, such as 10 in. × 5 in. **I** at 30 lb. and 12 in. × 5 in. **I** at 32 lb., which have relatively thin webs.

Floor Joists enclosed in Concrete.—It is generally admitted that steel beams as fillers or floor joists encased in concrete provide a much stronger floor, strength for strength, than if the concrete were omitted. Therefore it is only reasonable to make some allowance for this additional strength in design. At the same time it is necessary to bear in mind the restrictions as to stress and the proportion of depth to span required by the Act. The additional strength can be calculated by the usually accepted formula for computing the strength of reinforced concrete beams.

In order to keep within the limits of span to depth prescribed by the Act, we are justified in assuming that the depth of the beam is from the top of concrete assumed as acting with the beam to the underside of **I** beam.

After some interesting remarks regarding the question of rivet pitch, grillage bases, mansard work and wind pressure, the author concluded with the following remarks:—

CONCLUSION.

I would urge that all constructional engineers and draughtsmen should support the London Building Acts 1909 Amendment, and that the Concrete Institute should do all that is in its power to foster the better spirit of co-operation for harmonious working between the engineer who has to design and erect steel-frame buildings and the district surveyor who is appointed to see that the requirements of the Act are faithfully observed and complied with.

It may be thought by some that certain amendments to the Act would be desirable, but in this connection no concessions can be expected or obtained unless all concerned with the working of the Act combine together to make the very best of it as it is in its present condition.

As an Act it is both fair and practical, and time has already shown that it has been the means of considerably improving the general design of steelwork both from the standpoints of good practice, economy, and theoretical design.

Following upon the paper there was an interesting discussion, of which we here give a short account:—

DISCUSSION.

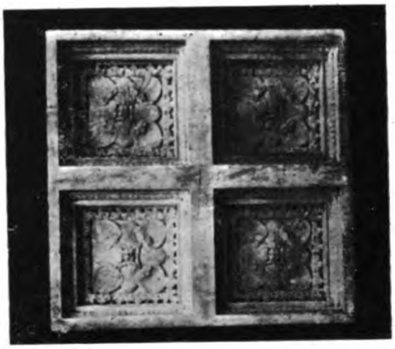
Professor Henry Adams, M.Inst.C.E., who was unable to be present, wrote saying he echoed the author's hope that all constructional steelwork might be carried out in accordance with the London County Council Regulations, whether legally subject to them or not; also that the steel-frame work should be directly under the control of an engineer, while the architect confined himself to the architectural features. He did not understand the author's relief at not being required to make allowance for the eccentric loading of beams. All competent draughtsmen had always been in the habit of making this allowance, and also both to provide for the structural load and the superimposed load. He did not agree with his statement as to what the eccentricity devotee would take for leverage distance on the pillar. With regard to the question of submitting calculations to the District Surveyor to enable him to judge of the sufficiency of the design, he agreed if his duty merely consisted of checking the arithmetical accuracy of the calculations, but if his desire, as he assumed it to be, was only to determine the efficiency of the design he should say, judging from his own experience in practical work, that the calculations were a hindrance rather than a help, as he found that the shorter way was to make his own calculations on the basis of the loads to be carried. Many of the author's approximations were very useful, but he did not agree that the depth of an unstiffened web might reach sixty times the thickness. He certainly never adopted so extreme a ratio. The author's tables of safe loads on standard beams massed in concrete would be found very useful. He had not seen any published tables of this kind before, though this method of construction had been largely adopted for the last fifteen or twenty years.

Mr. F. E. Wentworth Sheilds, M.Inst.C.E., thought that the interesting Paper fully justified the action that the Council and the members had taken, in doing their best to encourage Papers other than those on concrete and reinforced concrete. It showed how very closely allied the different branches of structural engineering were; indeed, that it was almost impossible to have a broad and comprehensive view of materials like concrete and reinforced concrete without some study of steelwork design also, and that the study of one was immensely advantageous to the study of the other. He agreed that the tables given at the end of the Paper, in which safe loads for British standard beams encased in concrete were given, were most useful and interesting. A little while ago he had occasion to consider a case of a floor which consisted largely of British standard beams encased in concrete, and he found that although the concrete casing added very considerably to the strength of the steel beam, it was almost impossible to take advantage of that fact because there was such a very high friction stress produced by the loading between the flange of the girder and the concrete. In this particular case the load was unusually high: ten cwts. to the square foot. He did not gather whether the author had gone into the question of friction stress between the steel and the concrete in making up these tables. This was a most important matter, because the concrete casing round a steel beam would only increase the strength of the steel beam provided that the steel and the concrete worked together, that was provided the beam did not slip within the concrete. If the beam slipped, then presumably the concrete casing was of little or no advantage to it.

Mr. W. G. Perkins (District Surveyor for Holborn) thought the author was distinctly wrong in stating that one was not required by the Act to make any allowance for the eccentric loading upon beams. What the true eccentric loading was it was difficult to say, but in the pamphlet published by the District Surveyors there was a formula given for taking into account the eccentric loading upon pillars, which might be taken as accurate for ordinary practical purposes. If the connections were made perfectly, the beams fitted tightly up against the pillars, and the pillars were continuous, then perhaps the bending moment might be reduced by 50 per cent., but as the Act allowed pillars being placed upon pillars they did not get that perfect continuity in the pillars, nor did they get the perfectly fitting joints, and in that case he thought the formula of the District Surveyors was the proper one to use. It was not theoretically correct, but they said in the pamphlet, as the buildings should be sufficiently braced that there should be no material deflection in the pillars the formula had been adopted in preference to the more complicated one necessary in cases where material deflection occurred. He should be very glad that the Institute should have a conference with the District Surveyors. As they generally had to work with architects, he thought at the same time they should invite the Royal Institute to send their representatives to such a conference. As Secretary to the Science Committee he would endeavour to do his best to bring about such a conference. The grillage was not really the foundation, the grillage was the base of the pillar; the foundation was defined in the byelaw as being the concrete, and if they regarded the concrete as the foundation and the pillar bore directly upon a series of grillage beams, which were properly stiffened and so arranged that the bearing load did not exceed that allowed by the Building Act, they could then take the grillage as the base of the pillar, and they would not be bound by the regulation which governed the rivets in the gusset plates. Referring to wind-pressure, he remarked that the general public were not acquainted with the failures that took place in and around London. As an old official it had been his lot to see several buildings which had been blown over in the neighbourhood of London by wind.

Mr. S. Bylander observed that if the Institute would adopt the recommendation of the author, that a Committee should consider the further regulations which might be required in order to make the Act for steel-frame buildings smooth working, he thought it would be welcomed by all concerned. Complicated and troublesome work they wished to avoid; they wished to simplify everything. If they knew exactly what to do they would work with greater pleasure. He would suggest that they should extend this still further, and that the Committee should recommend to the London County Council that they should supplement or amend the present Act as far as might be desirable. The author seemed to mix up the engineer and the contractor. His (Mr. Bylander's) idea was that the contractor would save a great deal of expense if particulars were provided by the engineer, and he was sure that the contractor would never be able to expect very definite and reasonable information and requirements unless it had been prepared by an engineer thoroughly conversant with the particular work. It had been proved to be successful that the quantity surveyor took out the quantities from one scheme prepared, and these were afterwards submitted to the contractors for tenders. On the question of eccentric loading for pillars, he for one thoroughly believed in the assumption that the load was applied on the centre of the beam and not on the face of the pillar. The assumption that the load was applied at the outer edge of the angle was thoroughly wrong. If there was a stiffener underneath it was most likely the load was applied uniformly over the bracket. He suggested that the allowable stress for pillars should include, say, 20 per cent. of the eccentric loading. This would simplify the calculations very considerably. His contention was that it did not matter a bit whether there were beams on four or two sides; the main thing was that the connection between beams, whether two or four, was sufficiently strong to hold the column lateral. He did not believe in the stiffening effect of the beam to the pillar by means of connections in order to keep the column rigid. As to beams buried in concrete, he thoroughly agreed that it was the adhesion between the steel beam and the concrete that they had to watch; that was an extremely difficult thing. He did not believe in the method of steel beams buried in concrete being the same as reinforced concrete. It was a most dangerous assumption. His alternative, which he thought would meet the case, was a much simpler one. A beam in solid concrete could carry a much greater load than a beam not supported in that manner. If the beam was embedded in concrete the floor would be three feet on either side. Then they should be able to allow a much higher stress. He further suggested that the stress of beams embedded in floors should be increased by, say, 20 or 25 per cent. This would give a fair allowance for the fact that the beam could carry a heavier load if not laterally supported. His belief was that before they got any considerable stress in the concrete they had reached the excessive stress in the bottom flange, and, therefore, they might at once dismiss the calculations of the top flange, and only consider the bottom flange.

Mr. Ewart S. Andrews, B.Sc.(Lond.), said there had always seemed to him a tremendous amount of misunderstanding on the part of engineers as to the failure of mathematicians to produce suitable formulæ for them. His own opinion was that directly practical engineers showed mathematicians that they really were interested in getting a formula which was accurate the mathematicians would rise to the occasion and give them that. The whole trouble was that there seemed to be a demand for half-baked formulæ, which did not satisfy the mathematician at all, and which looked sufficiently simple to satisfy the engineer. They seemed to be met by this call for simplicity, which he was sure was a very bad thing. It was impossible to reduce complicated formulæ into simplicity. He had given considerable thought to the question of eccentric loading, and he was quite in agreement with the main idea of Mr. Cocking's result. As to halving the eccentricity, though, he did not understand the mode by which he had attained it. The only way they would ever learn the actual stresses in the column was by actually measuring them, and the work that was being done in America at the present time in that direction was work that they ought to watch with very great care.



Sample of Panelled Ceiling Work done with Sand or Plaster Moulds.

THE DECORATIVE POSSIBILITIES OF CONCRETE.

By

C. W. BOYNTON and

J. H. LIBBERTON.

We give below an abstract of an interesting Paper which was read some time ago before the Western Society of Engineers, U.S.A., and reprinted in that Society's Journal (Vol. xviii, No. 8, 1913). The Paper was presented by Messrs. C. W. Boynton and J. H. Libberton, to whom we are indebted for our illustrations. The Paper comprised numerous other illustrations and examples which are not given in this abstract.—ED.

THERE is an old maxim to the effect that the designer should ornament his construction and not construct his ornamentation. This is an admirable saying, but should be subordinated to another rule, that he should ornament his structure only if he lacked the skill to make it beautiful in itself. A structure of any kind that is intended to serve a useful end should have the beauty of appropriateness for the purpose it is to serve.

There is a certain charm about a massive structure almost irrespective of design. The sight of a pyramid on the desk would call forth no expression of interest or enthusiasm, but let this grow in size until it assumes the proportions of those famous structures of Egypt and many pilgrimages will be made to view it. Of course the Egyptian pyramids are assumed to be the resting place of kings, and the placing of the blocks required the use of more muscle or machinery than we at present have any knowledge of, but our idea of their beauty and grandeur obtains primarily from the immensity of the structures.

There is no reason, however, why mass should not be combined with decoration, provided the design is not made subordinate to the decoration. This combination has often been used very effectively. The question is, what medium shall be chosen? At the Unity Church, Oak Park (*Fig.* 1), the building is not only monolithic concrete, but the ornamentation partakes of the same characteristics, having been cast at the same time and of the same material. In a building of this type, however, much attempt at decoration would be fatal, and the unobtrusive style adopted detracts not in the slightest from the dignity obtained by large areas and massive construction. With a different style of building, such as the Administration Building at Washington Park (*Fig.* 2), the treatment may be entirely different and the concrete be called on to assume the most intricate shapes.

Both of these buildings show the same surface finish. The architecture determines the decoration. With conditions reserved and the decorations transposed the effect would be ludicrous. In building the monotony of the form concrete has been relieved by the use of a rather dry surface mixture which

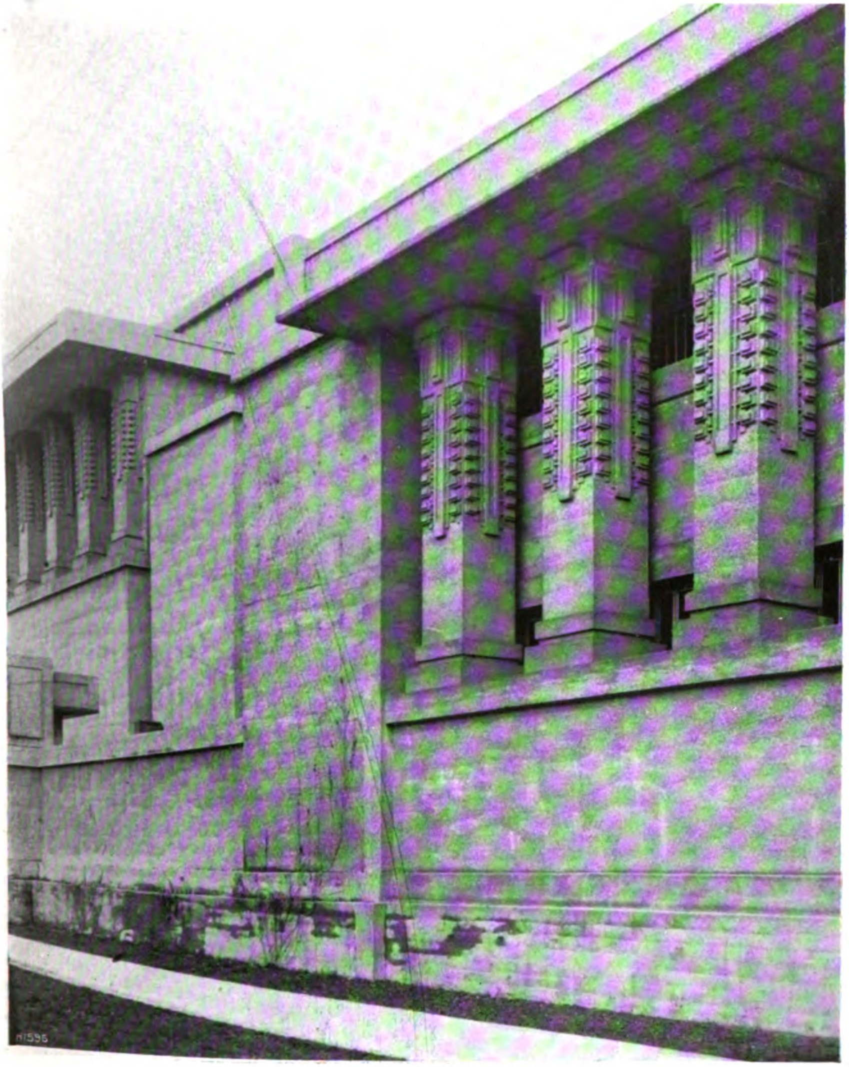


Fig. 1. Detail of Unity Church, Oak Park, Illinois.
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discloses the nature of the aggregate used. In work of this kind particular attention must be paid to methods of obtaining uniformity of surface and absence of horizontal joint markings, although the latter blemish is not nearly so noticeable on work of this character as with the wet mixture.

But the question of pleasing effects depends not only on the surfaces and the surface treatment, but on the combination of design with the surface texture. When not carried to extremes, the judicious use of a few division marks relieves the plainness of design and forms a rather interesting framework for what would otherwise be a monotonous surface.

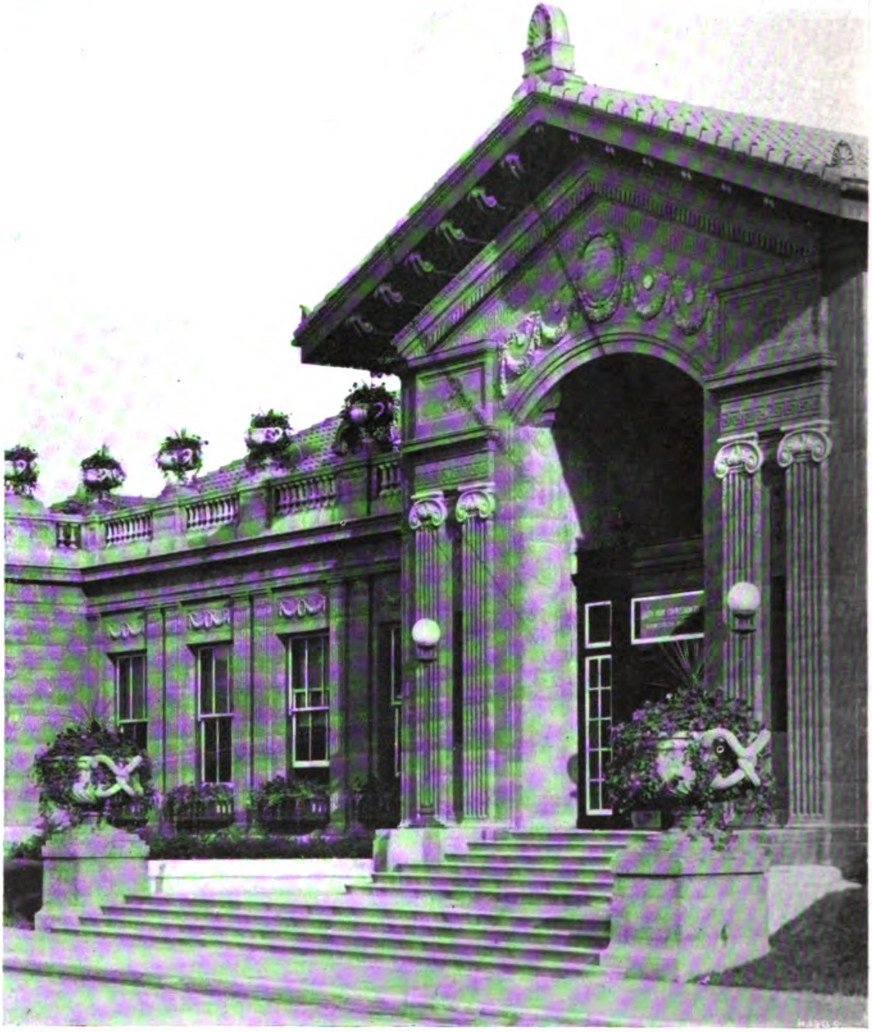

Fig. 2. Entrance Detail, Administration Building, Washington Park, Chicago.
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Decoration, however, is not an essential of mass construction, as has been clearly demonstrated by the Spanish in the design of the adobe dwellings and missions. But adobe perishes and our interesting relics of former days will soon be a thing of the past. Noting the possibilities of monolithic concrete for preserving this architecture, Mr. Frank Miller, U.S.A., has undertaken to petrify indefinitely, as it were, some of the most interesting details of the

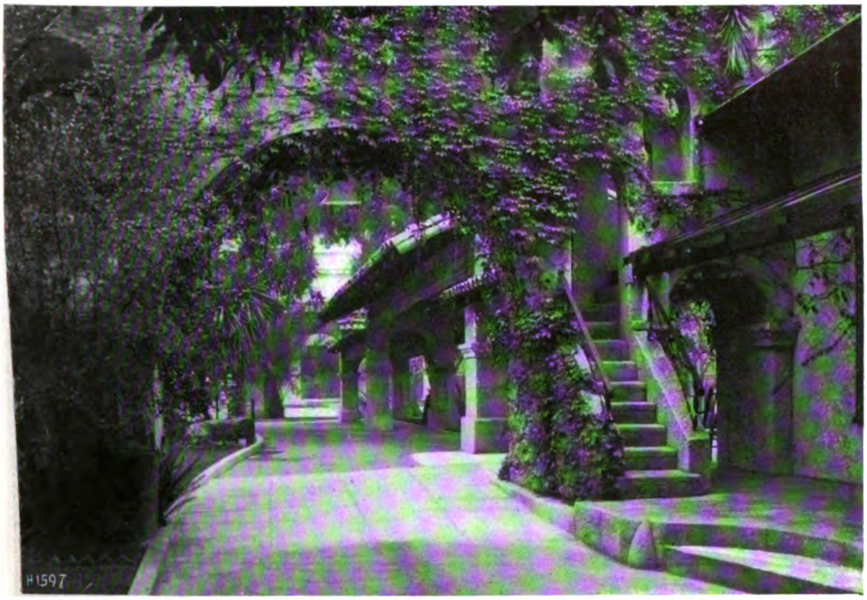

Fig. 3. Courtyard, Glenwood Inn, Riverside, Cal.

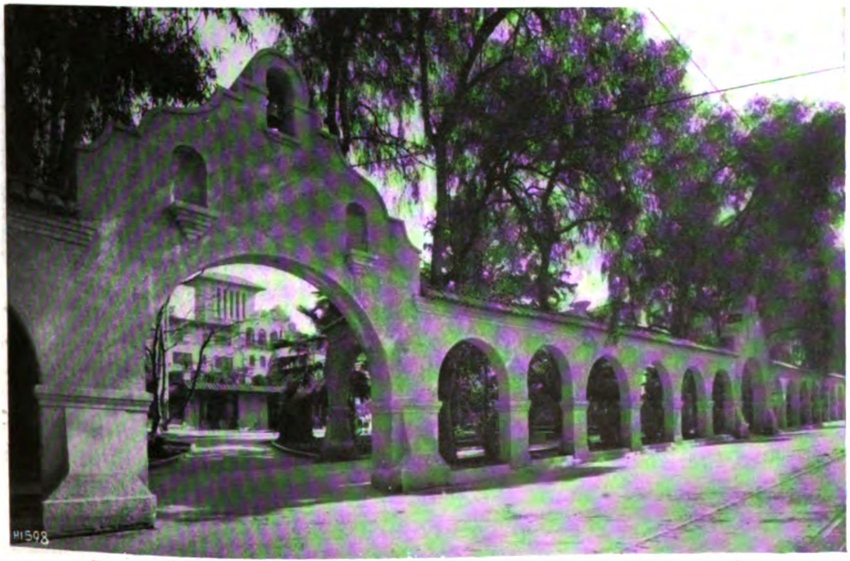

Fig. 4. Glenwood Inn, Riverside, Cal., looking from the street into the Courtyard.

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mission architecture developed by the Franciscan Fathers in California (*Fig.* 3). Thus when the last adobe wall has crumbled we still shall have a replica of the

Campanile of San Gabriel (*Fig.* 4) and the imposing arches of San Fernando, these having been duplicated in the Glenwood Inn at Riverside, California. Little other material than concrete has been employed—except the roof tile, which undoubtedly lend colour to the scheme and interest to the picture. On the roof is a famous collection of bells, over 300, dating back to 1278.

Of a mission type, also, are the rest or way stations of the Pacific Electric Railway, at Pasadena, California. These are fast replacing the old wooden rough and ready stations, none of which was consistent with the high class residential district through which the company operated. On both sides a bench is built into the wall so as always to furnish protection from rain.

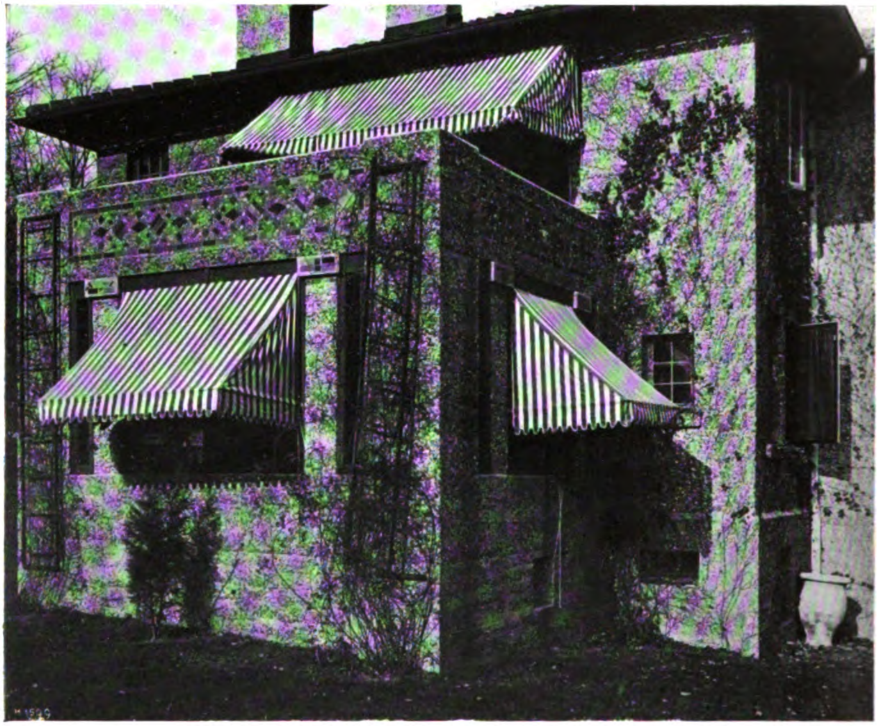

Fig 5. Porch Detail of a Residence in South Orange, N.J.
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Because it includes some of the most notable sculpture on the coast, the building of the Throop Polytechnic Institute at Los Angeles, Cal., may have interest. It is all of reinforced concrete. The sculpture was executed in New York and cast in glue moulds by a local company. Warm climates seem particularly suited to plain concrete construction, and its general adoption may partially be explained by the cool appearance of the plain surface.

Concrete, still in its formative state of development, is a comparatively new architectural material, although structurally it has been proving its permanence for many years. The particular reason for gratification comes in the new discoveries, and new uses to which it is continually being put. Every day something new and worthy of consideration is discovered.

Mr. Frederick Squires, of New York City, had viewed with regret the present slab and beam floor construction. After several years of study, he devised a method of duplicating the most intricate of cast ceilings in solid concrete, with a decided saving of material. His scheme consists simply in employing reverse coffers of moulder's sand, which are placed on the form before the concrete is poured. When the forms are removed, the panels are exposed, the whole being accomplished in one operation. Far more pleasing surfaces are obtained than were ever presented by the old plaster-of-paris method of applying previously cast panels to the work.

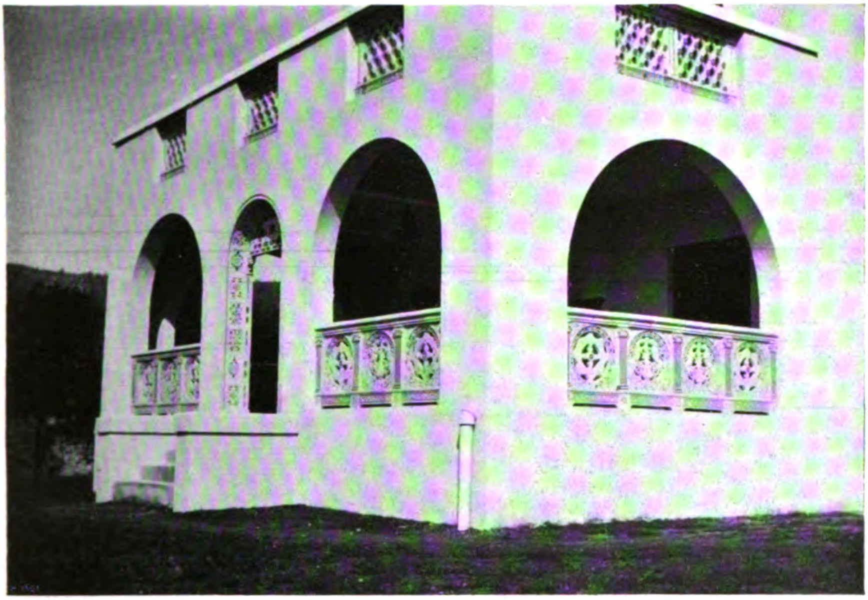

Fig. 6. **Porch Detail of a Reinforced Concrete Residence at Woodbury Falls, N.Y.**
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A few years ago the theory of applying concrete by means of a hose and nozzle met with derision, but every day we hear of more work being done by this method, the machine being designated as the "cement gun" and the concrete "gunite." An interesting piece of work has been accomplished by the Boston Elevated Railroad at the foot of O Street, Boston, where a garden fence has been constructed by this method. The base and posts are built of concrete poured into the forms in the usual way, the posts being relieved by protecting brick quoins. The street face of the panels were shaped by means of a wooden form, and each central panel was faced with steel. The concrete was applied from the rear with the cement gun, making the panels 2½ in. thick and the styles 4 in. thick. The interesting point in the operation is that the entire panels are made in one piece and at one operation.

The very fact that concrete is simple in operation has caused many to undertake construction who are in no way fitted to carry it out, but with proper supervision even the most unskilled labourer can accomplish pleasing results.

A building should be fitted to the country in which it is to be located, and more and more attention is continually being given to the unity which must exist between the landscape and the layout of concrete structures which are to be added as permanent improvements.

An interesting example of concrete for houses is seen in the detail (*Fig.* 5), the residence of Mr. Albert Moyer, U.S.A. Liberal use has been made of exposed aggregates, employing a mixture of Portland cement with limestone screenings, marble chips, and dark trap rock. Not stopping here, much dependence has been placed upon Moravian pottery decoration, which harmonises well with the concrete surface. The balcony, also, has been worked out in pottery. The distinguishing feature lies in the fact that instead of being inlaid, the figure comes out in bas-relief, and although somewhat serpentine in design, seems fairly consistent with the grape-vine motive.

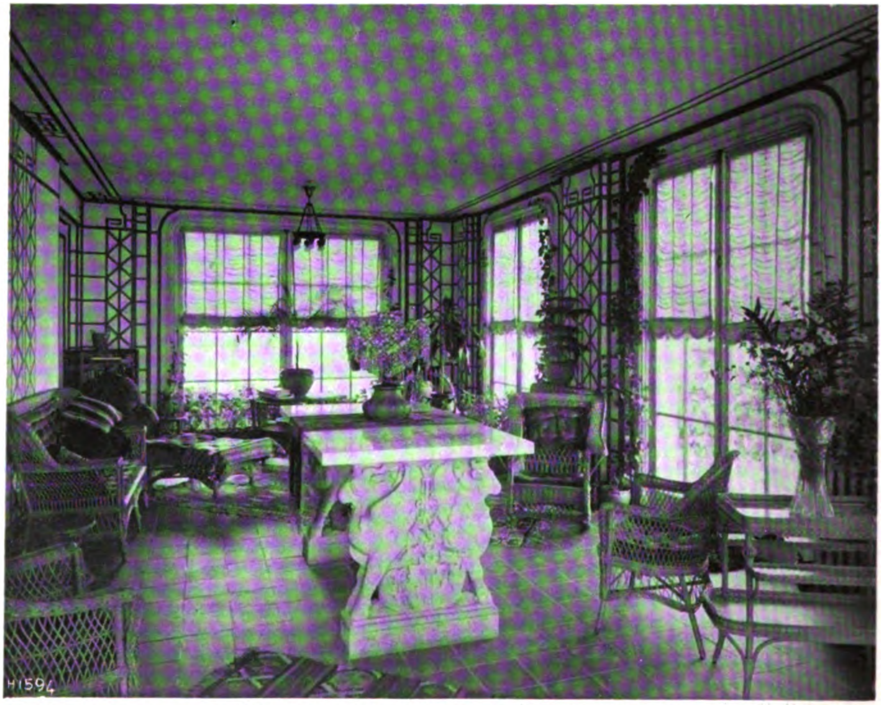

Fig. 7. Interior View of a Reinforced Concrete Residence, showing substitution of Fresco for Lattice Work.
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For some time Mr. Alfred Hopkins, of New York City, has been a strong advocate of reinforced concrete for the construction of buildings, and has added a large amount of information to our knowledge of the concrete of the old Romans, having investigated this point personally and in some detail. Nevertheless, he has never brought himself to believe that concrete should be used for the ornamentation upon buildings of the same material. For this purpose he advocates terra cotta. He has recently erected a large residence at Woodbury Falls, N.Y. This building is all of reinforced concrete to the roof, and part of this has been constructed of concrete slabs. But for the panels and column capitals terra cotta tile has been used. For the average individual, of course, a detail of this kind would be prohibitive in cost. But with such a sized undertaking as this mammoth residence, the high individual cost of these panels is small when compared with the total cost of the building. However, with the advances which are being made in the use of coloured aggregates, it is generally possible to obtain all the colour variations necessary in the concrete itself.

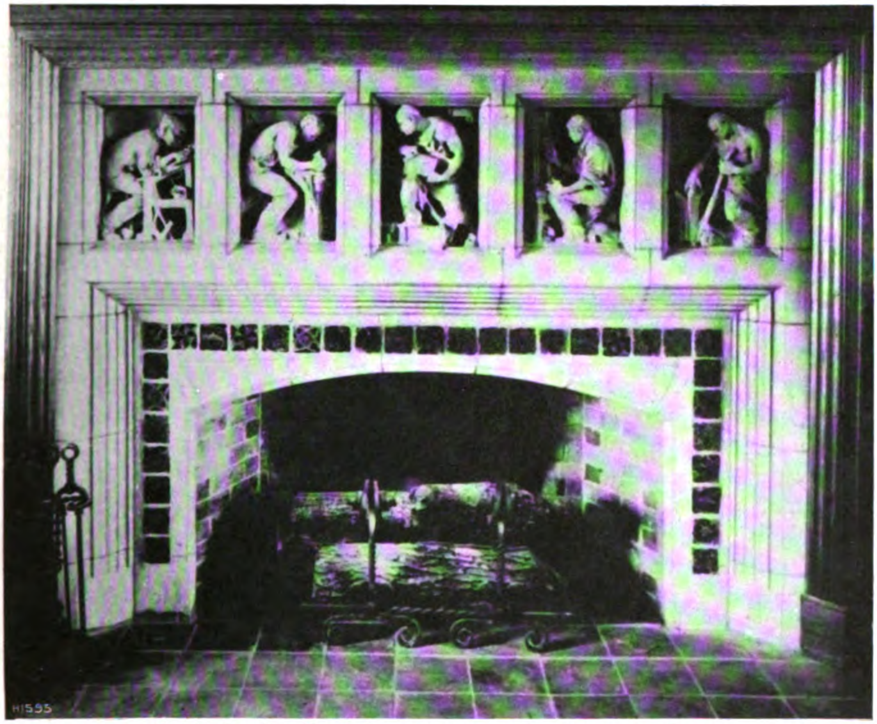


Fig. 8. Fireplace Detail, Eco .omy Concrete Co., New Haven, Conn.
THE DECORATIVE POSSIBILITIES OF CONCRETE.

It is not customary to build reinforced concrete roofs of the pitch type. In fact, there is no sensible reason for adhering to this construction when designing reinforced concrete. The ideal concrete house is built with a flat roof, not only because architecturally the design may be made pleasing, but because this type is the most economical in cost and space. An attic is of little use except for the storage of material which, in the majority of instances, will never be needed again, and when stored away in an attic corner invites spontaneous combustion. Reinforced concrete has brought with it a new architecture, and the sooner we appreciate its value the earlier will be the general adoption of reinforced concrete for residences as well as the endless other types of construction to which it has already been applied.

Lattice work has been utilised on important dwellings in combination with decoration of moulded concrete, and where some would use terra cotta, as in the panel inserts, others have used concrete, depending upon exposed aggregate to furnish the touch of colour needed. The lattice idea can be shown by simply stenciling the lines upon the wall, instead of using wood. (See *Fig.* 7.)

Wood panelling will also break up large areas of concrete surface, and is entirely in keeping with the old half-timbered style of architecture, so familiar to our forefathers.

Stucco finish has found favour when applied to concrete blocks as a backing, and there are some architects who believe that this is the only satisfactory means of handling what has seemed to be in many cases a sad makeshift so far as a building material having architectural merit is concerned. This impression has probably grown from the continued manufacture of rock-faced and inferior blocks by those who are entirely unqualified to undertake this kind of work.

It has been stated the so-called dry process concrete block is not of concrete at all. Having had little acquaintance with water during its process of manufacture, it consequently harbours an unquenchable thirst, and when used in the outside walls of a building proceeds to make up for lost time, every rainstorm furnishing the elements of a " spree " to the detriment of the block and the appearance of the dwelling. The dry process, however, is not necessary, it being equally as easy to add enough water to insure excellent concrete. The possibility of careful inspection during its manufacture is a strong point in favour of the continued use of this really excellent building material.

The Economy Concrete Company of Newhaven, Conn., have begun to demonstrate the possibilities of concrete for furnishing the ornamentation for buildings of other material. The fireplace here illustrated (*Fig.* 8) is composed principally of ornamental concrete stone. The figures above the mantel are moulded after the various workmen about the plant, with the exception of the one at the far right, who represents transportation. The other figures represent in their order (1) the draftsman laying out the plan, (2) the sculptor working over the pattern, (3) the labourer pouring the concrete, and (4) the workman putting the finishing touches on the surface and correcting any flaws caused by removing the forms.

The work is all cast in solid and uniformly proportioned concrete without special surfacing, using wooden or plaster moulds. Where necessary glue moulds are employed for the under-cut work. This, of course, gives a rather smooth surface, and is the only criticism which could be made of the product. With but slight additional expense, however, the surface can be chiselled so as to relieve what sometimes appears to be a rather putty-like surface when fresh from the moulds.

It should make no difference whether the stone trimming is artificial or natural, the end achieved is that upon which we should pass judgment. In reality, it matters not whether the aggregate in the concrete has been bonded by nature, or by the hand of man with Portland cement as the binding material.

So far as permanence is concerned, concrete has already proved beyond a doubt its superiority to many of the natural stones.

The writers, not being architects, have dealt somewhat sparingly with the subject of architectural and decorative possibilities of concrete, and have rather depended upon the illustrations to indicate the purpose of this paper. After all, architecture and architectural decoration is a peculiar study. On the one hand there are those who contend for close adherence to the ancient styles of architecture, and on the other hand we have many brilliant minds

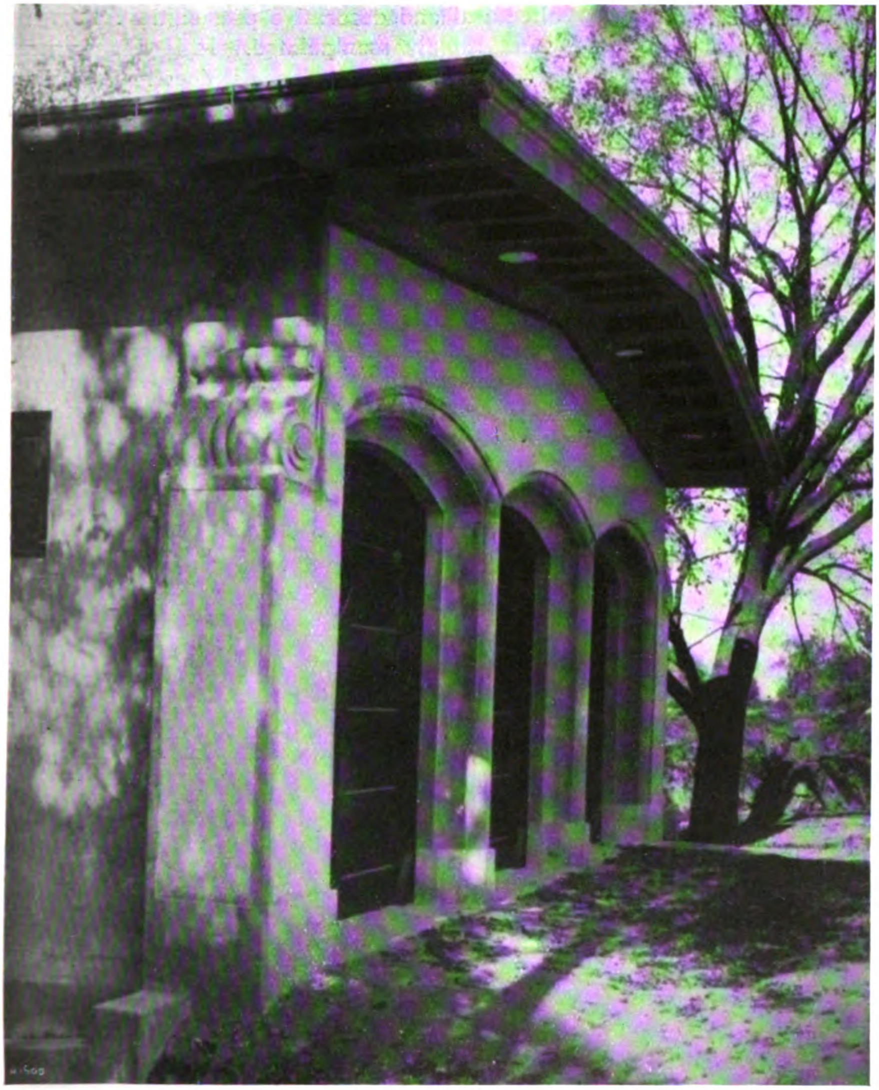


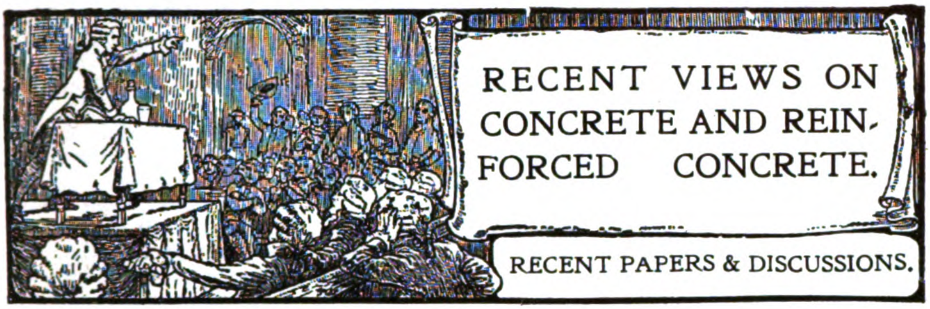
Fig. 9. Reinforced Concrete Fire Station at Weston, Mass.
THE DECORATIVE POSSIBILITIES OF CONCRETE.

who have achieved wonderful results and designed some of our most pretentious structures along entirely new lines, yet without voluminous criticism from those who consider themselves authorities. However, since this paper has dealt more particularly with the architectural side of concrete, it is, perhaps, fitting to close with a quotation from Mr. Oswald Hering, U.S.A., who has made a study of concrete and its architectural and decorative possibilities:

"Concrete can be easily and rapidly manipulated. It is less expensive than either clothed steel or masonry construction alone; it does not deteriorate with time, and it is practically fire and waterproof. It grows in strength for a considerable length of time, and after having attained its ultimate strength it never weakens, consequently by its use lighter, cheaper, and more durable structures may be erected than with any other known materials."

Regarding concrete stone he says:

"The time would seem to be not far distant when concrete will very largely supplant marble and stone where castings are practical. These should not be termed 'imitations' of stone, for the ingredients are largely the same as are found in real stone. Nature's process of employing time and gravity has simply been superseded and accelerated by man's mechanical ingenuity."



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

RECENT PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE NATIONAL CONFERENCE ON CONCRETE ROAD CONSTRUCTION, U.S.A.

CONTRACTION AND EXPANSION OF CONCRETE ROADS.

By Messrs. R. J. WIG, N. H. TUNNICLIFF, and W. A. McINTYRE.

An important Conference on Concrete Road Construction was held in Chicago in February, and numerous interesting Papers were read. One of the most important reports presented, says the "Engineering News," was that of the Committee on Contraction and Expansion of Concrete Roads. The Chairman of this Committee was Mr. R. J. Wig, of the Bureau of Standards. We give below a short abstract of this report and also of one on Aggregates for Concrete Roads.

THE data presented by this Committee show that the main cause of contraction and expansion of a concrete road, or for that matter of any concrete exposed to the weather, is not changes in temperature but *changes in moisture conditions.* While there has been more or less discussion of this subject by cement experts, it will come as a new idea to most engineers that concrete swells and shrinks every time it is wet and dried, just like a piece of timber, though of course not to the same degree. But it is established that the swelling and shrinking of concrete with changes in moisture is far greater than its expansion and contraction with changes in temperature. The Bureau of Standards has made most careful measurements on the experimental concrete road near New Village, N.J., and has found that the maximum expansion of the concrete in this road occurs in April when the road is thoroughly soaked by the winter's rain and snow and when the temperature has somewhat increased above that of the winter. The road then begins to shrink, notwithstanding the increasing temperature of summer, and is shortest in August when it becomes most thoroughly dried out.

One important lesson from this discovery is the importance of a rich impervious mixture for concrete road work, so as to make the percentage of water absorption and consequent expansion as small as possible.

Another very important result of this Committee's work is its recommendation that the sub-grade of the road on which the concrete is laid be slightly dished instead of made flat or crowning. This tends to prevent longitudinal cracking of the road, as gravity tends to cause the two longitudinal halves of the road to slide toward the centre, thus inducing compression in the road. Further, with the sub-grade dished and the concrete surface crowned, the concrete will be much thicker in the centre than at the sides, giving it greater strength to resist longitudinal cracking.

AGGREGATES FOR CONCRETE ROADS.

By Messrs. SANFORD E. THOMPSON, A. N. TALBOT, and W. M. KENNEY.

The successful development of the concrete pavement depends upon : (1) Materials, and (2) Workmanship.

It is not so much a question as to whether concrete is a suitable material for roads in comparison with other paving materials, as it is a comparison between concrete and concrete. The durability depends upon the character of the concrete.

Examination of letters received by the Chairman of this Committee from a large number of cities having concrete roads shows general satisfaction with this type of pavement. Adverse criticism usually comes from cities where the specifications and description of work indicate either poor materials and incorrect proportions or improper methods of construction.

AGGREGATE ESSENTIALS.

Simple rules covering the most essential requirements are as follows :—

(1) For fine aggregate, use only sand or other fine aggregate that has been actually tested for mechanical analysis and tensile strength of mortar, and is free from fine particles.

(2) Use coarse-grained sands or hard stone screenings with dust removed.

(3) Use sand or other fine aggregate that is absolutely clean.

(4) For coarse aggregate, use hard stone, such as granite, trap, gravel, or hard limestone.

(5) If bank gravel or crushed stone is used, always separate the sand or screenings and re-mix in the proper proportions.

If local conditions prevent following any one of these rules, adopt some other material than concrete for your pavement.

Briefly taking up each one of these points :

(1) Actual laboratory tests are necessary for fine aggregates, because it is impossible for the most expert builder to always distinguish by appearance between good and poor sands. Sand may be coarse, of good colour, well graded, and apparently perfectly clean, and yet because of a minute quantity of vegetable matter may show practically no strength when made into mortar or concrete. Case after case has been found where good-looking sand had to be rejected on laboratory test or, if used, produced defective concrete.

(2) Coarse sand is necessary not only for strength and density, but to prevent the formation, on or near the surface, of a layer of fine material, consisting of a mixture of dust and cement which has no durability. Mortar made with fine sand or sand having a large proportion of fine grains of silt, hardens slowly and is especially objectionable in cold weather. This prevents it attaining proper strength before the road is thrown open to traffic. A sand having a considerable proportion of fine particles may possibly show high briquette tests, and yet the mortar not have good resistance to attrition or wear.

(3) Sand must be absolutely free from vegetable or organic matter, or it is liable to harden not at all or too slowly to be serviceable. Frequently, sand may be entirely satisfactory in appearance, and yet be worthless for concrete. Defective sand of this type is apt to be taken from too near the surface of the ground, so that it contains a very small percentage of vegetable loam. At least 2 ft. of top soil and loam should be removed before using the sand, and in many cases it is necessary to take off as much as 4 or 5 ft., while occasionally no acceptable sand can be found in the entire bank because of the penetration to a great depth of the deleterious vegetable material.

(4) A coarse aggregate of hard quality is necessary to resist the wear and abrasion of hoofs and wheels. Failures of concrete roads have been caused simply by the softness of the coarse aggregate. In one instance, for example, shells were used for the aggregate, and the road went to pieces as soon as it was subjected to wear.

All stone, like shale, slate, shells and soft limestone, must be rejected; while trap, granite and conglomerate, are specially suitable materials. A hard limestone, such as that occurring in certain localities along the Hudson River, which is sold in New York as trap rock, is satisfactory for concrete roads. A hard limestone cannot be cut with a knife and the specific gravity is high, say, over 2·70.

Gravel does not bond quite so strongly with cement as does broken stone. When properly screened and free from dirt, however, and remixed with sand in the proper proportions, a good surface can be made even for a one-course pavement.

(5) Many roads that are now being built will prove worthless because of the use of sand taken directly from the bank without screening. If the gravel contains as much as 40 per cent. of stones and very rich proportions are used, say 1 part cement to 3½ parts bank gravel, a fair concrete can sometimes be produced, but it is always cheaper in such cases to screen the gravel and remix the sand and stone in proper proportions. There will be, for example, a saving of ¼ bbl., or 1 bag, of cement per cub. yd. of concrete by using proportions 1 part cement to 2 parts sand to 3 parts screened gravel, instead of using the unscreened bank gravel in proportions 1 : 3½. This difference will more than pay for the additional cost of screening the sand and rejecting part of it. At the same time, the result will be more uniform and the surface more durable because of the stones which take the wear. When an access of sand is used in the mixture, as is the case with run-of-the-bank gravel, the mortar rises to the top when the concrete is placed and the wearing surface is less resistant than a mix that is uniform throughout.

If the rules given above are followed, and at the same time proper foundations, proportions, and workmanship, are obtained, the concrete pavement will prove durable and will resist ordinary traffic.

Tentative specifications for aggregates are presented as follows :—

FINE AGGREGATES.

Quality.—Fine aggregate shall consist of sand or screenings from hard, durable gravel granite, trap, or other hard rock. It shall be clean, coarse, hard, free from dust, loam, vegetable, or other deleterious matter. Fine aggregate containing frost or lumps of frozen materials shall not be used.

Samples for Test.—Average samples of fine aggregate weighing not less than 10 lb. shall be taken from the bank or pile and tested, before the acceptance of the material, for fineness and for tensile strength in mortar. Individual average samples shall be taken from each bank to be used, and new samples taken in case of a change in the character of any one bank.

Receptacles for shipment to laboratory shall be such as to retain the natural moisture in the sand.

Fineness.—The size of the fine aggregate shall be such that the grains pass when dry a screen having ¼-in. openings. In the field a ⅜-in. mesh or, in some cases, a ½-in. mesh screen may be used for this separation.

Not more than 10 per cent. of the grains below the ¼-in. size shall pass a sieve having 50 meshes to the linear inch, and not more than 2 per cent. shall pass a screen having 100 meshes to the linear inch.

Tensile Strength of Mortar.—Mortars composed of one part Portland cement and three parts fine aggregate, by weight, when made into briquettes shall show a tensile strength at least equal to the strength of 1 : 3 mortar of the same consistency, made at the same time, and with the same cement and standard Ottawa sand. The sand shall not be dried before being made into briquettes, since this sometimes improves its quality, but correction shall be made for moisture when weighing the materials.

Tensile tests may be made at ages of 72 hours, 7 days, and 28 days. At early periods the strength need not attain the full ratio of 100 per cent. to standard sand mortar, provided this is attained at a later period. In no case, however, shall sand be accepted for pavement work whose strength in 1 : 3 mortar at the age of 72 hours is not at least 80 per cent. of the strength of the standard sand mortar.

Screening.—If bank gravel or crushed stone is used it must be screened and remixed in the proper proportions.

If the sand does not fulfil the above requirements for fineness, it shall be washed, or else screened when dry over a 10-mesh screen placed at such an angle as to remove the particles finer than a No. 50 sieve.

Washing.—Fine particles may be removed by washing with a large volume of water in a box provided in the bottom with perforated pipes and arranged for the silt and water to flow off through a trough from the top of the box and the sand to be drawn out from below.

COARSE AGGREGATE.

Quality.—The coarse aggregate shall consist of clean, hard, durable granite, trap, conglomerate, gravel, or other hard rock, free from dust, loam, vegetable or other deleterious matter. In no case shall coarse aggregate be used which contains frost or lumps of frozen material.

Coarse aggregate containing soft particles shall be rejected.

Coarse aggregate shall not contain a large proportion of flat or elongated particles.

Fineness.—For one-course pavements, the size of the coarse aggregate shall be such as to pass an inclined or rotary screen having 1½-in. circular openings and be retained on a similar screen having ⅜-in. openings.

For two-course pavements, the size of the coarse aggregate for the bottom course shall be such as to pass an inclined or rotary screen having 2-in. openings and be retained on a similar screen having ⅜-in. openings.

For the wearing course in a two-course pavement, the coarse aggregate shall be of a size that will pass an inclined or rotary screen having ⅜-in. circular openings and be retained on a similar screen having ¼-in. openings.

NATURAL MIXED AGGREGATES.

Natural mixed aggregates shall not be used as they come from the bank or crusher, but shall be screened and remixed in the proper proportions.

ASSOCIATION OF ENGINEERS-IN-CHARGE.

THE STORAGE OF COAL.

With Some Applications of Reinforced Concrete.

By HENRY ADAMS, M.Inst.C.E.

The following is a short abstract of a Paper read before the Association of Engineers-in-Charge, on March 11th, 1914. The lecturer illustrated the Paper by numerous lantern-slides, and quoted many examples of the application of concrete for coal storage, a number of which have from time to time been given in our Journal.

The author having been professionally concerned with the buildings, machinery, and vessels used in the seaborne and inland coal trade for more than half a century, it occurred to him that it might be interesting to put together a few notes on the storage of coal in the course of its transmission from the ship to the consumer.

Where open land is available the simplest arrangement for storing a large quantity, such as a whole cargo of 2,000 tons or more, at one time, is to prepare the ground by levelling and then paving it with creosoted fir blocks, or with rammed chalk. The latter makes a cheap and suitable bottom for a large storage ground as at Messrs. Wm. Cory and Son's Victoria Dock Depôt.

The space can be divided into bins for different qualities or varieties of coal by fences on three sides, composed of old railway sleepers let into the ground vertically for a foot or so, with old rails for longitudes, and old crane chains to form ties to prevent overthrow by pressure

The coal is lifted from the ship's hold in buckets containing 15 to 20 cwt. and transferred into small iron trucks run by hand along an overhead gangway or timber viaduct to reach the store and then tipped, temporary rails of 1½-in. square iron, attached to 7-in. by 2-in. fir sleepers, being laid along the heap as it progresses. Or, in other cases, the crane is so placed that it can lift from the ship or barge and deposit at once on the stacking ground, but in that case it is generally a long-rake electric crane or a steam crane travelling along a permanent viaduct as at Dowell's Wharf. The most recent arrangement is to have long radius cranes with self-acting grabs holding 15 to 25 cwt. to reduce the manual labour to a minimum.

The storage of coal is chiefly required by the merchant who sells to the dealers and to private consumers, and by the large corporations for their own use in the production of light and power.

The coal hoppers used by the merchants are built almost entirely of timber on a brick or iron column foundation, while those used by the corporations are mostly of brick.

There is always a risk of spontaneous combustion where a large quantity of coal is stored, but although the author has known of one or two cases, there is not much danger where it is kept under cover. In the various seaborne coal depôts there is always sufficient movement going on by coal going out and other coal coming in to minimise the risk. Spontaneous combustion of large collections of coal is more likely to happen when the cargo has been standing in trucks exposed for some time to rainfall, so that the coal is more or less damp throughout, but the subject is somewhat obscure, and is well worthy of a special Paper.

The question of the weathering of coal is of some importance. It has been established beyond doubt that coal exposed to the weather deteriorates and loses some of its calorific value. The Admiralty made some experiments upon storing coal under water, and it was alleged at the time that it kept better than when exposed to the air, but possibly that result was desired rather than proved. It is often necessary to store coal for some considerable period in order to take advantage of cheap markets, and also to avoid stoppages of work due to strikes in the coal trade; under these circumstances stacking to a height of about 6 ft. upon the ground is usually resorted to, and it is likely that a cover of tarpaulins would be of advantage.

The present century has, however, seen the introduction of a new mode of building which is peculiarly suitable for the construction of coal stores: reference is made, of course, to reinforced concrete. In this material, composed as it is of steel rods embedded in concrete, there is the maximum of durability and the minimum cost of maintenance. Structures of creosoted timber may last for fifty years, with increasing expenditure for repairs after the first fifteen or twenty years; but in fifty years a reinforced concrete structure will be in better condition than in the year it was built. It is probable that in the future this will be the only method of construction adopted for the purpose. It seems impossible to conceive of any better material; it has every advantage and no drawback.

A somewhat fanciful objection to the use of reinforced concrete is being put forward by certain of the opponents to the employment of this material for structural purposes—namely, that, in consequence of its monolithic character and its extreme hardness, the work of demolition, where such is needed, entails excessive costs. There is no doubt that the strength and toughness of buildings in reinforced concrete increase with age, and that in comparison with brick walling or even ashlar stonework, the expense of removal of the concrete is great, but the imperishable character of the structure and the small cost of upkeep are really great points in its favour. It is only in rare cases that new buildings have to be removed shortly after being built.

As an example of coal storage on a large scale, it may be mentioned that in connection with the cable way from the port of Savona to San Giuseppe are twenty-four rectangular storage bins for coal, each of 400 tons capacity, at Savona, and forty-eight cubic bins measuring 5 metres each way, and having a capacity of 100 tons each, at San Giuseppe.

At the Flossmühle paper mills on the Continent a coal silo, 87 ft. 3 in. by 9 ft. 6 in., with a capacity of 14,126 cub. ft. in five cells, was constructed in reinforced concrete immediately over the boilers, with a tower at one end in which the hoisting apparatus was fixed. The concrete piers were protected from the heat of the boiler fires by means of asbestos felt, but the author's experience is that no protection is needed even against the actual heat of hot fuel. Reinforced concrete bunkers should appeal to a large number of engineers as being at once a very economical method of storing coal for many minor purposes, such as mechanical stoker feeding, as well as hand stoking. Low in first cost, and with advantage of a negligible charge for upkeep, it can be safely said that for coal storage purposes the use of reinforced concrete is bound to become universal.

NEW WORKS IN CONCRETE

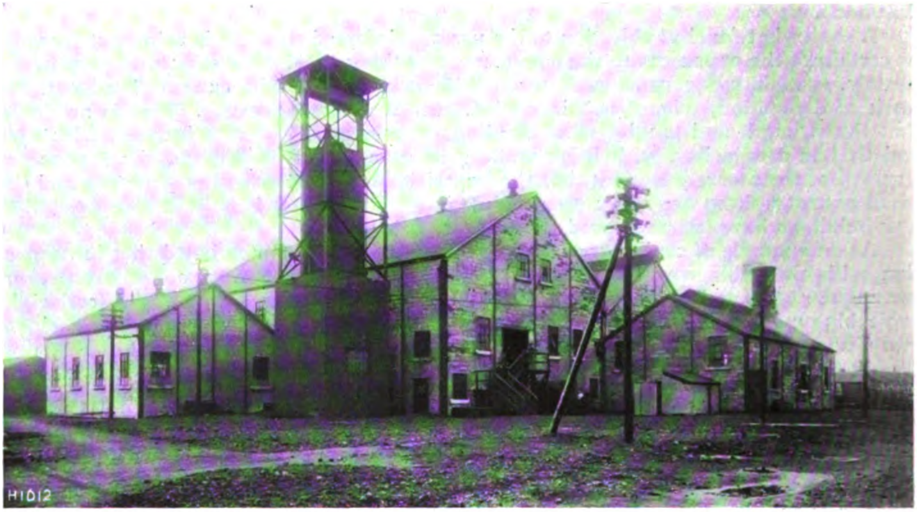
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

CONCRETE BLOCKS AT PORT TALBOT.

IN connection with the various improvements and extensions that have been made at Port Talbot and which are at present in hand, it is interesting to note the use of concrete blocks by the Port Talbot Railway and Docks Co. for the erection of their new hydraulic power station buildings. In the accompanying illustrations are shown some of the work which was carried out in hollow slabs. The buildings comprise the following:—

Hydraulic power station	97 ft. long by 57 ft. wide by 30 ft. to eaves.
Boiler house	97 ft. long by 57 ft. wide by 24 ft. to eaves.
Electric engine house	47 ft. long by 31 ft. wide by 19 ft. to eaves.
Economiser building	69 ft. long by 34 ft. wide by 17 ft. 6 in. to eaves.



CONCRETE BLOCK BUILDINGS FOR THE PORT TALBOT DOCK CO

The blocks and slabs used throughout were "Winget" blocks, made on "Winget" machines. The centres of stanchions vary from 10 ft. to 14 ft. The panel walls between the stanchions are built entirely of $4\frac{3}{8}$-in. hollow blocks from ground to eaves and ridges, and are of the same thickness throughout without any steel reinforcements of any kind, with the exception of the reinforced concrete still carried across the stanchion foundations to support the walls.

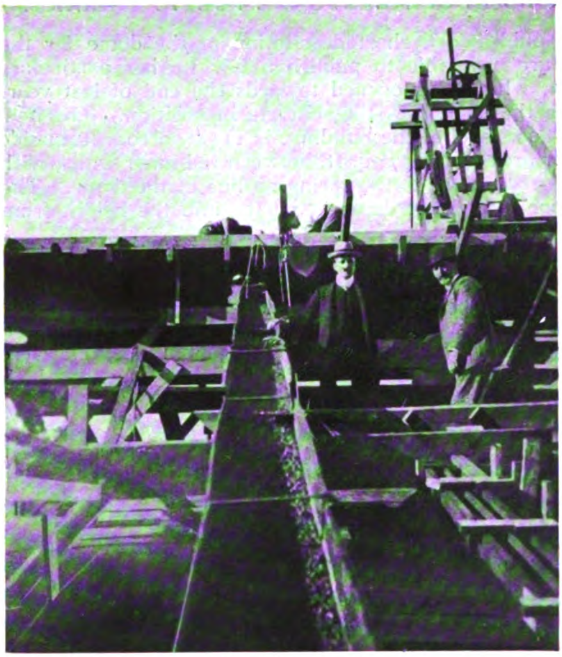
The engineer to the Port Talbot Railway and Docks Co., Ltd., is Mr. W. Cleaver, M.Inst.C.E., under whose supervision this work was carried out.

PLACING OF CONCRETE FOR DOME OF MELBOURNE PUBLIC LIBRARY.

In our December number we published a short description of the dome for the Melbourne Public Library. We are now able to publish a few further particulars regarding the new Reading Room, which was opened towards the end of last year. Our notes have special reference to the placing of the concrete in position. The new reading-room, situated on the first-floor level of the building, is 115 ft. across from side to side of the octagon, giving a floor area of 10,957 sq. ft. between the inner walls, with a clear height of 80 ft. from reading-room floor to the springing line of the dome. The clear height from reading-room floor to apex of dome is 116 ft., and the height from basement of building to apex of dome 150 ft.

For the purpose of placing the concrete a platform about 20 ft. square was erected above the central lantern light and carried by the timber centering below. The materials used for the concrete were 1 part cement, 2 parts good coarse sand (specially selected), 3 parts bluestone screenings up to $\frac{3}{4}$ in. gauge. These materials were stored in basement, so as to have no stoppage of work due to shortage of material, and were mixed by hand in a thorough manner in the basement, shovelled into trucks, which were immediately wheeled on to the cage of an electric hoist and thus lifted up to the platform level above the dome. The concrete was dumped from the trucks on to the platform and immediately shovelled by hand through hoppers in the floor of the platform, discharging into the heads of chutes, by means of which it was conveyed by gravity to the various positions required on the dome. These chutes were made in portable lengths of sheet iron with a timber support to bottom thereof, and were 12 in. wide by 5 in. deep. The slope of the chutes was approximately 30° to the horizontal, and it was found that the concrete, which was mixed fairly wet, ran down the chutes evenly and without any segregation of the constituents. The concrete was discharged directly into the position desired, where it was continuously rammed and spaded into position round the reinforcing bars. In this way about 8 cub. yd. of concrete was placed per hour. In placing the concrete the buttresses were done first, followed by the heavy ring at the springing of the dome, suitable toothings and skewbacks being left to take the concrete to be placed subsequently. In placing the concrete in the ribs of the dome the eight main angle ribs were done first; the diametrically opposed ribs

CONCRETE BLOCK BUILDINGS FOR THE PORT TALBOT DOCK CO.



CONCRETE SHUTE.

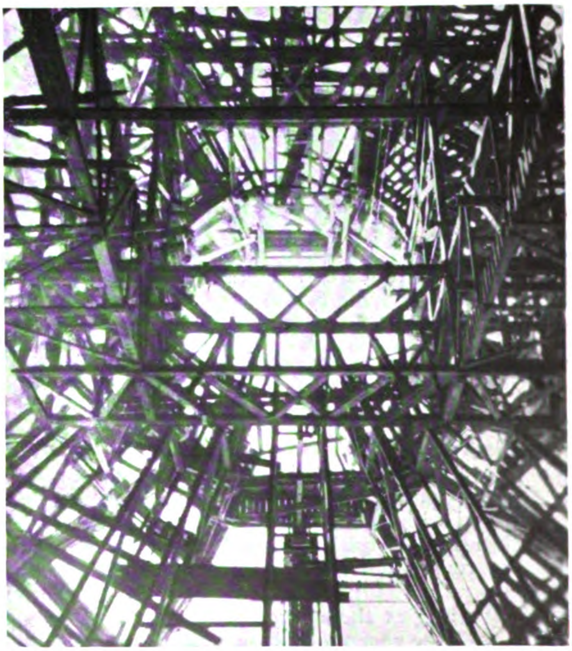
and portions of the adjacent purlins and slab were carried up simultaneously from the springing to within 4 ft. of the ring at the apex during each day. The eight intermediate ribs were then similarly constructed, this bringing all the ribs up to within 4 ft. of the ring at the apex. The concrete to all ribs was stopped with a face at right angles to the axis of the rib at that point and additional rods put in projecting beyond the face to give additional bond to the new concrete.

The concrete ring at the apex was then placed in one day, special care being taken to get a good bond with the upper faces of the ribs by cutting same back and well grouting in cement mortar.

The concreting of the remaining portions of the purlins, the dome slab, 6 in. thick, and the walls of the lantern light was then proceeded with.

As soon as possible after the completion of the concrete work, which was kept wet by the application of water, the whole of the exterior face of the dome was cemented with 3 parts sand and 1 part cement and finished with a steel trowelled surface.

The timber centering was left in position for four months after concreting was finished, and was then gradually eased by slacking off the wedges on top of the wood trusses; these were slacked off from the springing, first working towards the centre. It was found that these wedges came away easily, apparently carrying little weight, no doubt due to the gradual shrinkage of the timber. The total downward deflection of the apex of the dome on the removal of the centering was $\frac{3}{16}$ in. This was measured by taking readings on a graduated rod suspended from the apex of the dome by means of a surveyor's level stationed on the flat roof over the annulus. This deflection re-



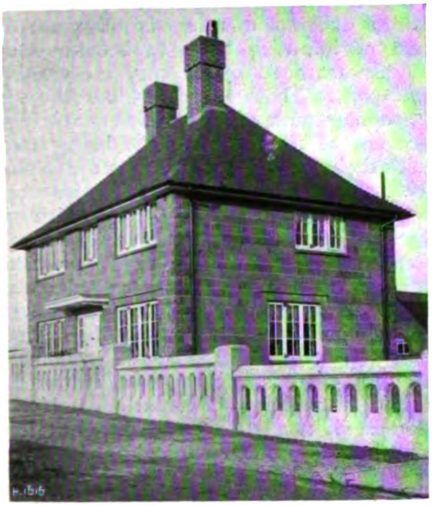
View looking up at Central Lantern Light, showing Timbering for Dome
MELBOURNE PUBLIC LIBRARY.

mained constant for three days, when it was found necessary to remove the rod. Up to the present the dome has stood well.

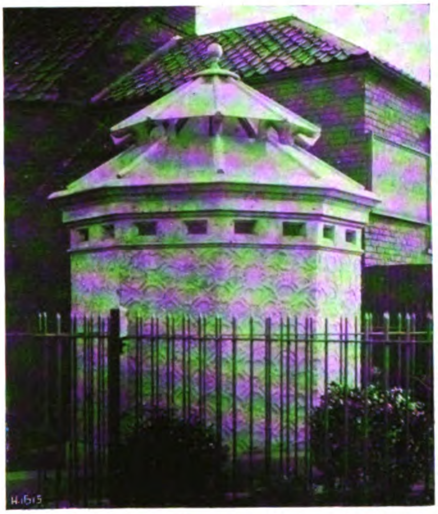
The contractors for the work were Messrs. Swanson Brothers, master builders, who carried out this extensive and difficult work very satisfactorily, and the structural work was under the supervision of Mr. Chas. P. Smart, B.C.E., of the firm of Bates, Peebles and Smart, the architects for the building, and we are indebted to him for these additional particulars.

CONCRETE BUILDINGS AT NORWICH.

The accompanying two illustrations show some small concrete buildings recently erected at Norwich by Mr. Arthur Collins, the City Engineer, to whom we are indebted for our photographs. The buildings are useful in showing the application of concrete and reinforced concrete for small buildings.



Concrete Dwelling-House for Foreman Engineer at Norwich Main Sewage Pumping Station.



Reinforced Concrete Urinal at Norwich.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Concrete Products" by "Hollie."

London. The Anglo-German Publishing Co., 15 Craven Street, Strand, W C. 125 pp.

This little volume has much to recommend it on account of the very practical manner in which it is written, and the author has imparted a freshness to his work which is seldom met with, and which renders the book very interesting to read.

Before dealing with the matters described in the book, we should like to draw the author's attention to a remark made by him in the preface—viz., "There is not a single English book dealing with this branch of industry. All the information a man interested in concrete can obtain is an occasional article in one or other of the building journals." We were under the impression that our journal dealt very fully with all kinds of concrete work, and that we published more than an occasional article on this matter, but either we are mistaken or the author has not studied the premier journal devoted to his special subject.

Facts and comparisons are drawn between concrete bricks and clay bricks, and although we are advocates of concrete, we are afraid that the writer has somewhat missed the essential points, especially when dealing with the question of appearance, as the artistic taste has not been considered, and the very irregularity of a clay brick in colour and shape is the thing which appeals to the architect, and after all he is the person who adopts and specifies the material to be used.

We would call the author's attention to the latter part of page 7, where he says. "Measure and examine it whichever way you concrete blocks opposite." There is evidently something wrong here, and we fail to see the author's meaning.

Comparisons are drawn between nearly all classes of concrete products and those produced in other materials, and the advantages of concrete are very strongly stated, but the writer in all cases is reckoning without the æsthetic instincts of the true designer. The various materials used in the making of concrete are dealt with in detail, and the plant required for the production of various commercial forms of concrete is described and illustrated with many useful recommendations.

In dealing with partition slabs the author does not mention the all-important fact of allowing these to become thoroughly seasoned before they are used in the work. These slabs have become very unpopular with many architects solely on account of unseasoned slabs being used, with the result that contraction takes place afterwards and cracks appear in the work, whereas this is not the case with the various hollow brick partitions. There is no need for this unpopularity if manufacturers will only see that their products are fit for use when delivered to the site.

The book is well illustrated throughout, and despite our criticisms we recommend it to our readers as being well written and full of interesting information, which is presented in a style quite different from that found in most technical works.

Fire Tests with Floors.

A Floor of Reinforced Concrete reinforced with Triangular Reinforcement and presented for test by Messrs. Naylor Bros., Huddersfield. Red Book, No. 188 of the British Fire Prevention Committee.

Published at the offices of the Committee, 8 Waterloo Place, London, S.W.

At a time when the question of reinforced concrete is largely before the technical professions, and the question of regulating such structures is receiving the attention of the public authorities concerned, a Report issued by The British Fire Prevention Committee (as Red Book No. 188) dealing with a fire test on a reinforced concrete floor with triangular lattice reinforcement may be deemed to be of special interest.

The prefatory note to the Report indicates that in comparison with other floor tests, the instructive feature of this investigation is that granite chippings do not appear so satisfactory from the fire point of view as some of the other materials that have been used in the Committee's tests, and further, that the question of protecting the soffit of the reinforced concrete beams requires careful attention.

It speaks well for the system of construction and the form of reinforcement used that, regardless of what appears to have been an unsatisfactory concrete aggregate, the floor stood up so well and obtained The British Fire Prevention Committee's classification of "Full Protection, Class B," which means a 4-hour test with temperatures reaching 1,800°F., followed by the application of water from a steam fire engine, and it is obvious that if a better form of concrete had been used, and the question of protection had received more consideration, an even better result with less deflection must have been obtained—*i.e.*, a result that would have practically left the floor in such a condition that it need not be taken down for reinstatement after a severe fire.

The British Fire Prevention Committee is testing one or two large floors every year, and, apart from the non-proprietary systems of construction that they have tested, a number of patented systems have now obtained the highest classification, which gives them a special claim for employment by the public authorities and corporations with whom safety from fire is a matter of importance.

Some thirty floors have now been tested by the Committee, of which about half were proprietary floors, and half floors in common use.

"Transactions and Notes of the Concrete Institute." Vol. V., Part I.

Published at Denison House, 296 Vauxhall Bridge Road, S.W.

This volume in its preliminary pages contains some notes regarding the membership of the Institute and contributions to its library. A new feature is the short review given of new books received. The remainder of the volume contains the papers read at the meetings of the Institute, together with a verbatim report of the discussions. The papers here dealt with refer to the "Settlement of Solids in Water and its Bearing on Concrete Work," by Dr. J. S. Owens; "Steel Frame Buildings in London," by Mr. S. Bylander; "Economy in Reinforced Concrete Design," by Mr. J. A. Davenport; "The Strength of Cement," by Mr. H. C. Johnson; "Props and Beams in Mines," by Prof. Stephen M. Dixon, and two reports of the Reinforced Concrete Standing Committee. All these have been dealt with in summary, with extracts from our report on the discussion, in our journal.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Manchester Building Trades' Exhibition.—A Building Trades' Exhibition was held last month in Manchester under the auspices of the various local Building Associations. The Exhibition was opened by the Lord Mayor of Manchester. There were many features of interest, but it would be impossible to make reference to the many exhibits shown, and we must therefore confine our reference to just a few which are of special interest to readers of this journal. Among those who exhibited were :—

Messrs. Bells United Asbestos Co. (Northern Agency), who showed their "Poilite" asbestos cement tiles and sheets. This material, as is known, can be used for roofing tiles, for walls, and ceilings, etc. The exhibit in this instance also showed the roofing material actually as applied to different classes of buildings.

The British Fibro Cement Works, Erith, showed a simple type of building roofed with their patent "Fibrocement" slates.

The British Portland Cement Manufacturers, Ltd., London, E.C., had a most interesting stall, which was primarily of an educative description, and the ever-increasing uses for Portland cement were adequately illustrated. The Company showed reinforced concrete fence posts and fencing, concrete drain pipes, and every kind of garden ornament such as flower vases, columns, etc. The use of concrete on the farm and estate was also shown and demonstrated. The exhibits also included briquettes, cubes, examples of suitable and unsuitable aggregates for mixing Portland cement, and also apparata for determining the voids in aggregates.

The Cyclops Concrete Equipment Co., Manchester, exhibited their concrete block and other machines.

Messrs. Ironite, Ltd., London, exhibited their waterproofing material for rendering waterproof structures such as tanks, reservoirs, tunnels, pits, etc., where there is heavy water pressure. The material can also be applied to floors, roofs, fencing, etc.

Messrs. Sano, Ltd., of Manchester, exhibited their jointless composite flooring and wall covering, and which can be laid on every kind of floor.

Messrs. Vulcanite, Ltd., showed the various ways in which their vulcanite waterproofing material could be used. The principal feature of their exhibit was a model swimming bath waterproofed with vulcanite lining.

Some New German Regulations Regarding Reinforced Concrete.— New regulations were issued last November by the Berlin Police Authority for the construction of reinforced concrete ribbed floors—that is, of floors constructed of reinforced concrete beams the panels between which are composed of bricks, hollow blocks, or specially devised objects in addition to the ordinary panel of reinforced concrete. Such systems of construction, mainly in patented forms, have come into frequent use in recent years, and special regulations for their use have thus become necessary. The regulations of May, 1907, have therefore been modified and extended in some particulars so as to cover the new conditions.

The use of hollow blocks, etc., cemented together but without the use of a reinforced concrete panel, is not permitted. The thickness of the panel was fixed by the regulations of 1907 at a minimum of 8 cm. ($3\frac{1}{4}$ in.), but where the filling blocks are rigidly united by pure cement mortar, it is permissible to reduce this to 6 cm. ($2\frac{1}{2}$ in.). The shearing stresses are to be determined for the thinnest part of the rib, and where this is so small that the concrete can only be cast, must not exceed 2·5 kg./cm.^{2}, but where thorough ramming is possible, up to 4·5 kg./cm.^{2} may be allowed.

As a rule, each rib is to be reinforced with one rod, and only when the breadth of the rib at the level of the reinforcement exceeds 6 cm. is a greater number of rods allowed. When computing the distance between the rods and the lower surface of the beam, the thickness of any plate which is attached for the purpose of giving a smooth under surface is to be included. The ribbed floor must bear on the supporting walls at least 13 cm. (5¼ in.), and must not be employed as a stiffening member. The ribs are not to be further apart than 60 cm. (2 ft.) from centre to centre, except where the filling material is grooved blocks of a special type, cemented together, when the distance may be extended to 75 cm. (2 ft. 6 in.). In dwelling houses, floors with exposed ribs must receive a finishing coat of cement.

Floors built into the walls on each side must be computed with a moment of $\frac{pl^2}{8}$ but in special cases, when the erection of walls and floor proceeds simultaneously and the fixing is shown to be sufficient, a moment of $\frac{pl^2}{10}$ may be assumed. In such a case alternately one reinforcing rod must be bent up and the other carried on.

Where ribbed floors are continuous over several spans the same rules apply as with other reinforced concrete floors, provided that the reinforcement is carried on continuously. That is, the floor cannot be regarded as continuous when carried by steel beams, but only when carried by reinforced concrete beams and properly constructed. For such floors, the bending moment is to be calculated on the assumption that one span is fully loaded and the neighbouring spans unloaded, as long as the working load is below 1,000 kg. per square metre; with heavier loads the most unfavourable loading is to be assumed. Negative moments are to be computed as if both spans adjoining the bearing were fully loaded.

Floors of the Koenen type are to be computed with a constant moment of $\frac{pl^2}{18}$ for middle spans and $\frac{pl^2}{12}$ for end spans, whether carried by steel or reinforced concrete beams.

Certain other regulations, referring to special forms of construction, require drawings for their illustration.

Port Talbot Dock Works.—In connection with the additional coal tipping and wharfage facilities at the above docks, it is interesting to note that reinforced concrete will be used largely. A 900 ft. long reinforced concrete wharf is nearing completion, and a further wharf of reinforced concrete is under construction. An extension of 100 ft. is also being made to the Crown Fuel Works Wharf. We hope to give full particulars and illustrations in a later issue regarding the concrete and reinforced concrete work in connection with the improvements in hand at these docks.

Reinforced Concrete and Rheumatism.—Our contemporary, the *Builder*, recently contained an article under the above heading. The writer of the article states that :—

"There are a great many different fungi, which are all produced by spores falling upon favourable soils in favourable positions. There are a great many different forms of rheumatism, and they also are all produced by spores or micro-organisms.

"Sunlight and dryness are unfavourable to the growth of the spores either of fungi or of rheumatism, while darkness and dampness seem to be favourable to the growth of them all. Therefore it will be wise to see that all human habitations shall at least be dry and light in order that no spores of any of these plants shall be produced in the vicinity of mankind during the hours of leisure and of rest."

He then quotes numerous cases which have come to his notice and attention. He states that the "modes of preventing the pre-existing enfeeblement of vitality which conduces to the catching of rheumatism are of course manifold." It is, however, pointed out that these methods are for the most part beyond the power of the physician to affect, but that the remedy lies rather with the architects and builders. The writer points

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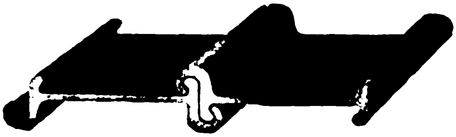

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out that it is the homes of the people which must be kept free from the spore-bearing conditions. In order to effect this we must " produce dwellings in which the conditions are inimical to the growth of spore-bearing organisms." The article continues: " If ' the material interests of the subject races are the guiding principle of Imperial Government,' let the material interests of our people be the guiding principle of our municipal authorities. Let the rich build of what materials they like; but let every municipality see that the workman's dwellings be impervious to wet and to cold and to vermin—almost to flood and to earthquake and to fire. In fact, it should be built of ferro-concrete. Is there a cheaper, cleaner, stronger, healthier building material known to man? "

The writer then points out that as " warmth is essential to overcome one of the most prevalent ailments of our climate, and if ferro-concrete be a building material most likely to prove prejudicial to spore-bearing diseases, but is too rapid a conductor of heat to make comfortable dwellings for mankind, it is up to the building profession and to those familiar with the multiple requirements of the case to erect workmen's dwellings of a non-porous solid that shall yet be not too quickly affected by atmospheric alterations of temperature, since every virtue has its failing, and the sharpest knife must be handled with the greatest care. One of the faulty virtues of ferro-concrete is that it prevents the penetration not only of damp but of air, while those porous materials to which we have hitherto trusted for the building of our homes have literally leaked at every pore. We have been accustomed to respire through wall and ceiling and floor, while the wallpapers and plaster of our rooms, if not indeed the very bricks of the walls, have proved veritable filters of germs, letting out indeed noxious gases from our apartments but retaining with certainty (in the absence of visible openings) every germ for future potency of infection.

" With the use of a non-porous building material all this automatic imperfection of ventilation must be exchanged for a purposeful system of architectural efficiency.

" As smooth, cold surfaces are not conducive to comfort for leaning against at home, all ferro-concrete walls in the house should be lined with a porous and washable dado; while parquetry flooring should replace the boards to which we have been too long accustomed.

" Still greater warmth would be secured by double walls with the necessary air space between, carefully secured from communicating at any point with the interior of the house; while a roughened surface to the outer wall and a padded roof would complete the essentials of sanitary dwellings conducive neither to rheumatism nor rheumatics."

Scottish National Portrait Gallery.—H.M. Office of Works shortly propose reconstructing the Scottish National Portrait Gallery in Edinburgh. The gallery houses a very valuable collection, and the object of the scheme is to protect the building as far as possible from fire. Concrete floors covered with parquetry will substitute the present wood flooring, and the roof will be of concrete.

Concrete Electroliers.—A new concrete office building in Los Angeles has secured a very pleasing effect in its design by combining electroliers as a part of the architectural plan. These are of concrete and rise from the cornice in the building about 10 ft. in height. They terminate in 5-ft. lights which form a cross.—*Concrete Cement Age.*

A Concrete Village.—The Delaware, Lackawanna and Western Coal Co., of Pennsylvania, U.S.A., have put up for their employés a model village, to be known as Concrete City, which forms an interesting example of a settlement of this kind. The houses are two-story structures, 50 ft. by 25 ft., built of concrete, with flat roofs and dark-green " trimmings." They are moulded in one piece. Floors, walls, roofs, stairways, even sinks and wash-basins, are said to be made of " poured " concrete. They are so constructed that, on occasion, the furniture may be all removed and the entire house thoroughly washed out with a hose. Each house contains seven rooms, and has stationary wash tubs, a buttery, and a good dry cellar. Wooden strips are embedded in the floors so that carpets may be tacked down. Below the French windows, opening outward, window boxes for flowers are set in the walls.

[INQUIRY.]

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

I am presently interested in the design of a block of buildings. It is proposed to run combined reinforced columns and pilasters up the outside of the building; these pilasters to be moulded.

I shall be glad to know if you can give me any information as to suitable treatment of the external face of the pilasters to ensure that they will have evenness of colour and a smooth and artistic appearance after completion of the building.

As you are aware, the difficulty is usually to prevent patchy and white discolouration and also to prevent small surface cracks when the building has been up for some time.

The pilasters, of course, could be washed over with cement grout or plastered with cement mortar, but it is proposed to discard both of those methods and to treat the concrete, after striking the boarding, either by rubbing down with a float when the concrete is green, or by any other method to ensure a good external surface and appearance for the concrete.

If you can give me any advice as to this I shall be obliged.

Yours faithfully,
ENQUIRER.

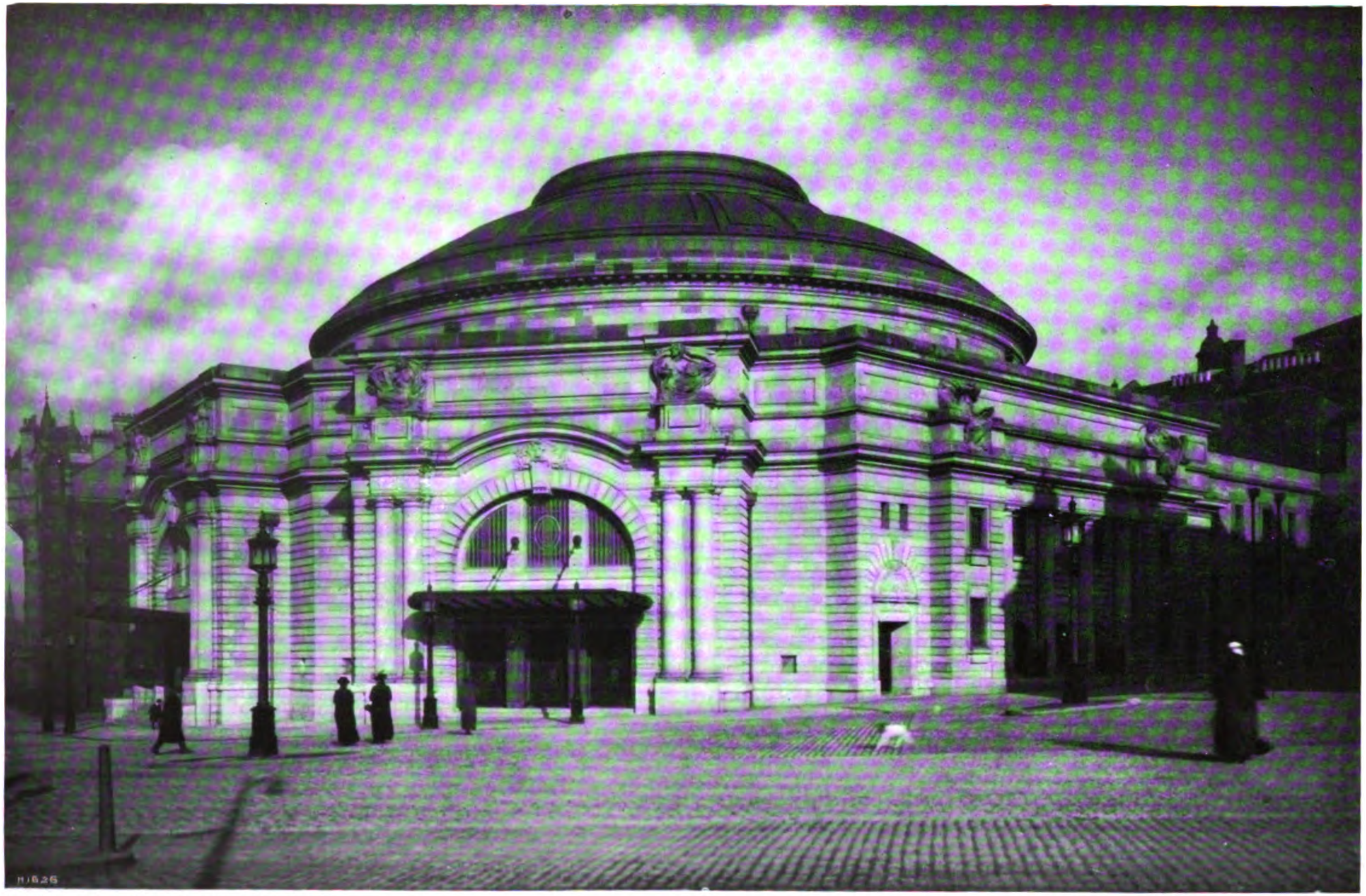
[*REPLY.*]

If it is definitely decided that no surface finish such as cement grout or cement and sand is to be applied, the only method we can suggest for obtaining a smooth surface is to have the shuttering very carefully and well constructed, with absolutely close joints, and a planed, clean surface towards the concrete. The latter should be carefully placed with fine stuff against the forms and no large aggregates should be allowed to get against the external faces. After the boarding is removed, the surface should be rubbed down with a steel float if the concrete is sufficiently green, or sandpaper or suitable stone may be employed to rub off any projections.

The Interim Report of the Concrete Institute on the Surface Treatment of Concrete, published in this journal last year, contains some useful information on the subject, and there are also some suggestions for surface finish in a book recently published entitled " Cassell's Reinforced Concrete."

ERRATUM.

We are asked by Messrs. Edmond Coignet and Co. to say that through an oversight it was stated in their advertisement on page v. of our February and March issues that the new Law Courts at Jamaica were executed by Messrs. Cowlin and Son, whereas this work was carried out by Messrs. Mais and Sant, of Jamaica.



Photographer, F. C. Inglis, Edinburgh.

View of Completed Building.
THE USHER HALL OF MUSIC, EDINBURGH.
(For Description, see p. 293.)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume IX. No. 5. LONDON, MAY, 1914.

EDITORIAL NOTES.

THE CONCRETE INSTITUTE.

Public Opinion.

THE Concrete Institute was the subject of an extensive leading article in our last issue, with the result that we have received much correspondence regarding its objects, its administration and its work. Further, the "referendum" post-cards we issued with the April number, with the object of obtaining some idea as to the views of our readers regarding the proposed change of the Institute's title and the change in its objects, have been returned to us in considerable numbers, only one reader differing as to its tenor and about a dozen as to certain portions thereof.

From the post-cards and correspondence, we realise that the general interest in the Concrete Institute's unfortunate doings is even greater among the public —*i.e.*, non-members—than we anticipated, and that the broader and national aspects of its existence or failure appeal to a large section of the professional world and to a very substantial section of the industries directly and indirectly concerned.

It thus appears to us, that if a section of the Council of the Concrete Institute pursues its present course of pressing for a change in the Institute's primary objects, so that concrete and reinforced concrete only play a secondary part, the more influential section of the general membership—including practically all the professional members abroad and many in the provinces—will retire from it at the end of the current year, whilst even with its present constitution better work will have to be done in the interests of concrete and reinforced concrete on lines that do not lay themselves open to such frequent and justifiable criticism.

The Institute's Administration.

A change of President is impending through effluxion of time. It is to be hoped that, whoever the new President may be, he will take office with the full confidence and good wishes of the Institute's Council as a whole, and not through any "arrangement" which would undermine confidence and be fatal to the Institute's prestige. There are rumours that something of this kind is being attempted. The Institute has had troubles enough without seeking this fresh one. On the other hand, a popular President of recognised standing and administrative ability could do much towards framing the Institute's policy and obtaining good management and courtesy towards its membership.

Again, some of our provincial correspondents tell us that owing to some legal quibble they are not to be consulted on any change, present or future, in the Institute, unless they happen to be temporarily staying in London, or can afford the time and trouble to travel specially to town to record their vote. Some 250 members resident abroad are apparently to be kept in the same position. In other words, close on three-fifths of the Institute's membership is to be permanently disfranchised at the behest of a section of the Council. Nothing could be more unwise than to offend the country and the Colonial member, no matter what the legal aspects of the Institute's rules may be. Why, even in public trading companies of standing the member at a distance can generally lodge a *proxy*, or if he cannot do so, is asked by courtesy to record his opinion in some informal way.

GENERAL CONCRETE USES IN ITALY.

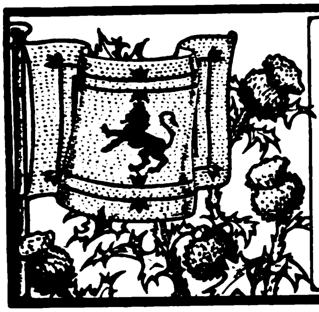
In an early issue of this journal we pointed to the readiness with which the Italian was using concrete for every possible purpose. Visiting Italy this year the traveller would be struck more than ever by the increasing use of Portland cement concrete for everyday requirements in town and country. Everywhere in Italy the praises of the material are being sung with no uncertain voice.

Leaving aside legitimate constructional work, where concrete now plays the premier *rôle*, one marvels at the adaptability of concrete where it is popular. Every form of sanitary appliance now appears to be made of concrete—the sewer, the pipe, the trap, the gully, the slop sink, the pantry sink and draining "board," etc. It is used for pavement work, both for the roadway and the footpath, kerbs of every form, corner posts, lamp posts and tramway poles, refuse boxes and sandholders, electrical control boxes and fire alarm posts. Every little culvert, open drain, chute, etc., is being made in concrete. Again, the material is in use for fence posts, kilometre posts, and even signposts on the high roads, not to speak of seats and benches, horse troughs and ornamental fountains of excellent taste.

The gardener appears to use it for rockeries, borders, and for all the odd jobs for which timber is generally the gardener's mainstay at home, such as props, shed work, frames.

In many cases old iron rods, gas piping, barrel hoops are made use of as a rough-and-ready reinforcement, and by some intuition and rule of thumb they are generally placed in fairly suitable positions.

To advocates of concrete, its ready application in town and country in Italy is now quite a revelation. We only wish the "handy man" in England would realise how economical and practical is its application. Much time and money would be saved and the wastefulness of constant painting, repairs and renewals avoided.



THE USHER HALL of MUSIC, EDINBURGH.

The special attention of our readers is called to the following article on the Edinburgh Usher Hall, owing to the extensive use which has been made of reinforced concrete for a building to be used as a place of public entertainment. We have often dwelt on the fire-resisting qualities of this form of construction—qualities so essential in a building of this description—and we would here like to draw attention to the fact that the material lends itself well to dignified architectural treatment, as will be seen from a glance at the illustrations.—ED.

General Description.—One of the most important features in the construction of the recently opened Usher Hall, Edinburgh, is the extensive use which has been made of reinforced concrete.

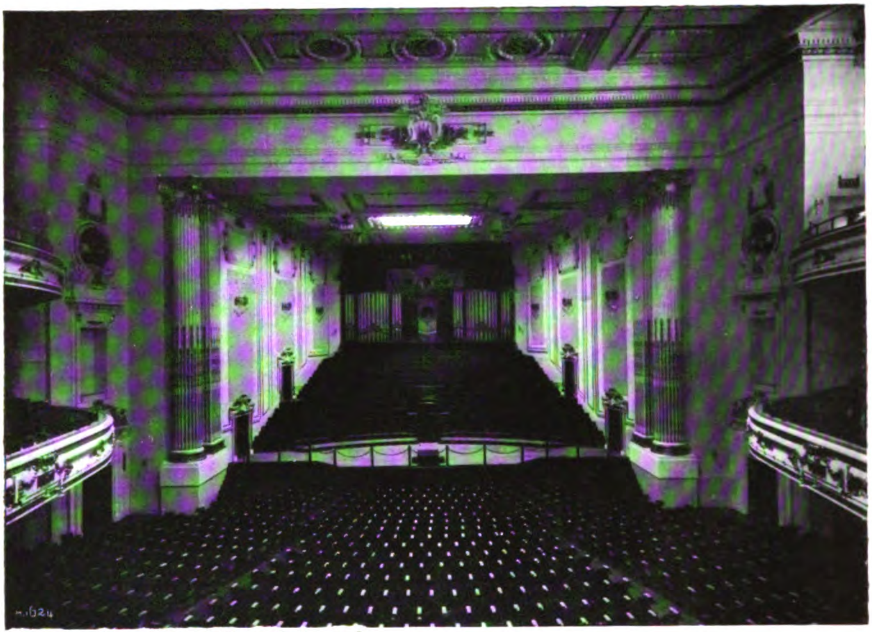
Reinforced concrete has been employed by the architects for the construction of the whole of the foundations of this structure; a large portion of the retaining walls below ground level; the internal pillars supporting the heavy masonry outer drum wall and dome roof; the Grand Tier gallery in cantilever; the Upper Tier gallery in cantilever; the whole of the floors, beams and lintels; the horizontal air ducts; and the roofs. To such an extent has reinforced concrete been used in the design of this hall that it may be said that the whole of the interior acts as one monolithic mass, clothed by the outer architectural walls of stone.

The style of architecture may be termed "English Renaissance" and the exterior is simple and dignified.

Above the base course, which is of grey Aberdeen granite, the outer walls are of cream coloured Darney sand stone. A view of the exterior of the hall is shown in the Frontispiece.

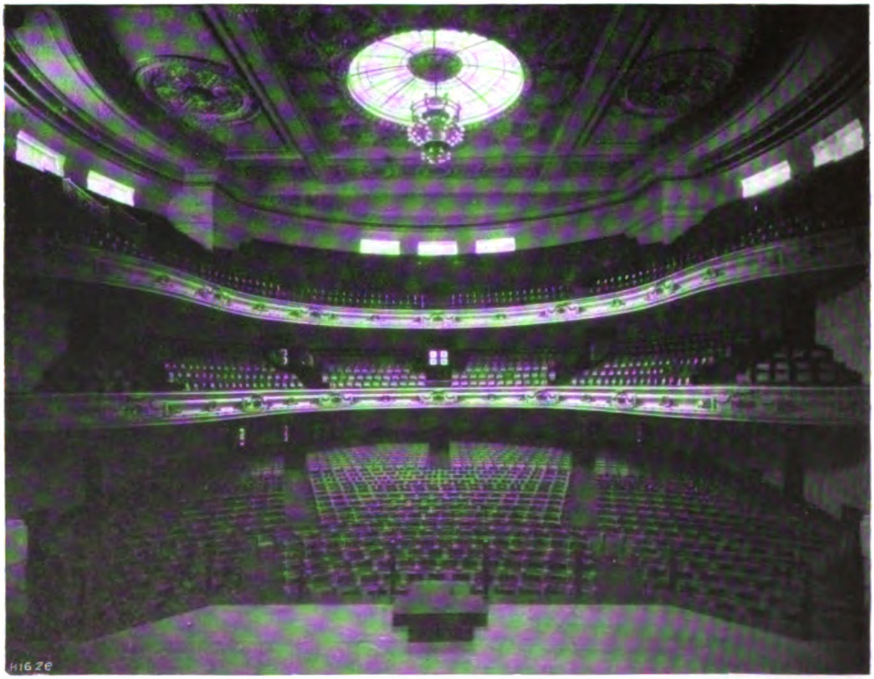
The hall covers an area of approximately 28,500 sq. ft., and is surmounted by a dome which rises to a total external height above the lower foundation level of 113 ft. Internally, the apparent height of the auditorium is limited to 60 ft. by the introduction of a flat plastered panelled ceiling, for acoustic reasons. The internal diameter of the circle formed by the outer drum wall enclosing the auditorium is 117 ft. The length from the front of the concert platform to the back of the Grand Tier gallery on the centre line of the building is 93 ft. and to the back of the Upper Tier gallery 104 ft. The proscenium opening is 65 ft. wide and has a depth of 60 ft., in which there is an intake to the concert platform on each side, making the width of the orchestra at the organ front 48 ft. Behind that is the organ chamber, 42 ft. by 18 ft. in size.

There are two foyers on the Grand Tier level, each 38 ft. by 23 ft. 6 in., and a central crush hall, also 38 ft. by 23 ft. 6 in. The circular corridor, from which there are five large access doors to the auditorium, is 9 ft. in breadth and has a total length on the circle of 280 ft. At the ends of the corridor—one at each end—are spacious cloak rooms, each 38 ft. by 15 ft. The foyers



Photographer, F. C. Inglis, Edinburgh.]

Fig. 1. Interior of Hall looking towards Organ.



Photographer, F. C. Inglis, Edinburgh.]

Fig 2. Interior of Hall showing Cantilevered Galleries.

THE USHER HALL OF MUSIC, EDINBURGH.

and crush halls are floored with reinforced concrete covered with marble. The cloak rooms and corridor are floored with reinforced concrete covered with polished oak block flooring.

The arrangement of the entrance hall, crush halls, cloak rooms and corridor are the same in all respects on the ground floor as on the level of the Grand Tier. On the Upper Tier gallery level there are five crush halls, three in the centre, leading from one to the other, each 38 ft. by 24 ft., and all lighted by means of dome lights from the roof. The crush halls at the ends of the gallery corridor are each 49 ft. by 15 ft., and are similarly lighted.

On each side of the concert platform at the east end of the hall are spacious retiring rooms for singers, instrumentalists, etc.

There is also a wide circular corridor beneath the raised tiers of seats in the orchestra, with a stair opening for artistes leading directly up into the centre of the concert platform.

On the top flat there is a large kitchen and scullery accommodation.

Under the concert platform, and separated from the remainder of the hall by means of a reinforced concrete floor, there is a sunk basement covering approximately 6,800 sq. ft., which is occupied as a boiler house in connection with the heating apparatus, and as mechanics' workshop, chair store, and extraction fan house for the ventilation of the hall.

The extraction fan exhausts from a circular underground duct constructed of reinforced concrete, and running round the auditorium, into which the vitiated air from the hall is drawn and exhausted outside into the open. This duct is 8 ft. 6 in. square internally, and has a total length of 290 ft. The chamber for the intake, purifying, and heating of fresh air for the supply of the hall (known as the "Plenum Chamber") is placed on part of the roof of the Upper Tier gallery crush halls at the Cambridge Street Lane side of the building, and the outer walls of this chamber, which is circular in form, are constructed of heavy masonry in keeping with the remainder of the building.

The internal floors and roof of the Plenum Chamber are constructed of reinforced concrete, and the whole dead load of this structure, which is of two stories in height, and including the heavy masonry walls, the reinforced concrete floors, roof, and heavy machinery installed therein, are wholly supported on a system of reinforced concrete beaming at roof level of the crush halls. It may be mentioned that the Plenum Chamber contains two powerful fans driven by electro motors, and also batteries of radiators for heating the air. The air, after being purified and heated, is driven through openings in the flat plaster ceiling under the dome into the auditorium. The crush halls, cloak rooms, and corridors are heated by means of radiators.

The stairways at the front entrances to the hall are constructed of reinforced concrete and covered with marble. The remainder of the various inside staircases are constructed of Leoch stone, and, where necessary, are supported by a system of reinforced concrete stringer beams.

In the auditorium the fronts of both the Grand Tier gallery and Upper Tier gallery are of horse-shoe design, and are constructed entirely of reinforced concrete covered with fibrous plaster.

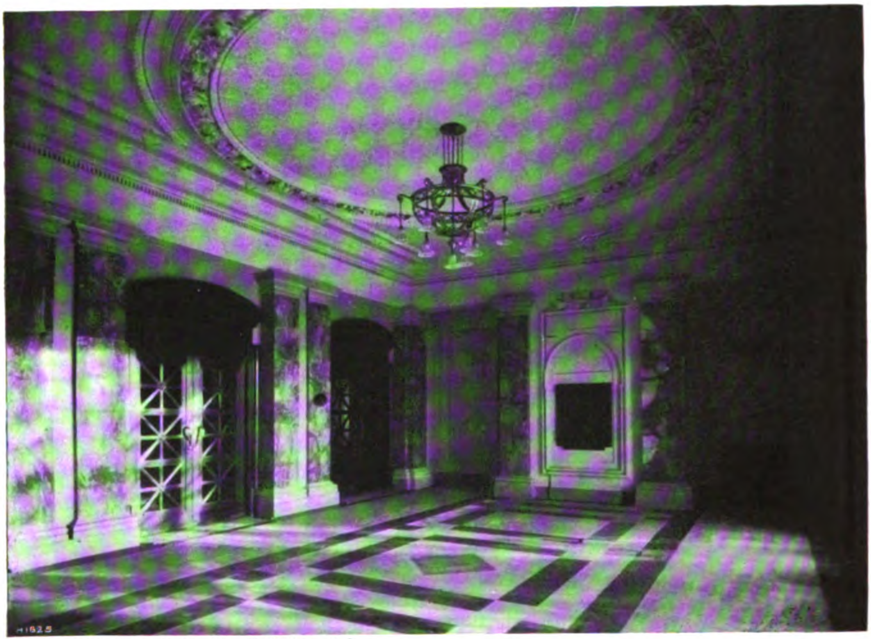
The reinforced concrete degrees of both cantilever galleries have been covered with oak flooring.

The galleries and area are provided with tip-up seats. The floor of the area has a rake of 4 ft. 6 in. from the last row of seats at the back to the platform.

The level of floors at the back of the area therefore corresponds with the level of the platform.

In the orchestra the seats rise in tiers, arranged in segmental form. The following is a summary of the seating accommodation:—Area 1,192, Grand Tier 428, Upper Tier 813, Orchestra 349, Platform 120; total, 2,902.

The foregoing brief description gives an outline of the general arrangements of the hall. The interior of the auditorium, even when filled, gives an impression of vastness, due to the fact that the reinforced concrete galleries have been constructed in cantilever. The adoption of the cantilever principle in the construction of the galleries is advantageous, as there is not a single pillar within the entire auditorium to obstruct the view of the concert platform and organ from any seat in the hall.



Photographer, F. C. Inglis, Edinburgh.]

Fig. 3. View of Main Entrance Hall.
THE USHER HALL OF MUSIC, EDINBURGH.

Attention may be directed to the photographs which show the beautiful decorative effects obtained, showing that the architects have been aided rather than hampered by the almost exclusive use of reinforced concrete in the structural part of the work.

The following is an appropriate summary of the total cost of the hall and its site:—Site, £36,000; buildings and furnishings, £94,000; organ and case, £4,000. Total cost, £134,000.

Reinforced Concrete Work.—The reinforced concrete foundations were designed to spread the loading so as not to exceed a maximum pressure on the ground of 3 tons per square foot, and the general arrangement and reinforcement of these foundations is as shown on the working detail drawing reproduced in *Fig.* 5.

It is interesting to note that owing to the careful calculation and design of these reinforced concrete foundations there has not been the slightest sign of unequal settlement in the whole of this extensive structure, a matter of extreme importance to the cantilever galleries in this building.

From the longitudinal section (*Fig.* 6) it will be seen that a reinforced concrete retaining wall has been constructed round the outer circle of the underground air duct. This reinforced concrete wall is designed to act not only as a retaining wall but also as a foundation beam, serving to distribute the isolated loads carried into it by the reinforced concrete pillars which spring from it at the level of the floor over the duct, supporting the weight of the superstructure and main dome roof. For this reason a uniform thickness of 24 in. was adopted for this retaining wall for its entire length of 290 ft.

The construction of the underground air duct is completed by a reinforced concrete floor, 6 in. in thickness, this floor being constructed to slope uniformly at either side with the slope of the internal area of the auditorium. The duct is 8 ft. 6 in. square internally.

The reinforced concrete pillars on the outer drum wall supporting the Grand Tier and Upper Tier cantilever galleries and floors, and also the main dome roof, are artistically clothed in Sienna marble.

On the Grand Tier level the horizontal area of the gallery in cantilever projecting beyond the supporting inner drum wall is approximately 3,100 sq. ft., and is supported by 28 reinforced concrete cantilever beams, the maximum outhang of these cantilever beams on the centre line of the building being 20 ft. 7 in. beyond the inner surface of the supporting wall. These cantilever beams form one of the most interesting features of the reinforced concrete work.

Fig. 8 shows an elevation of part of a Grand Tier cantilever beam; the maximum depth of these beams is 3 ft. 6 in., diminishing to 11 in. at the extreme outhang.

The web of the back portion of the cantilever beam is pierced by 3 openings, each 1 ft. 10 in. in diameter, for the passage of air in the duct under the Grand Tier corridor.

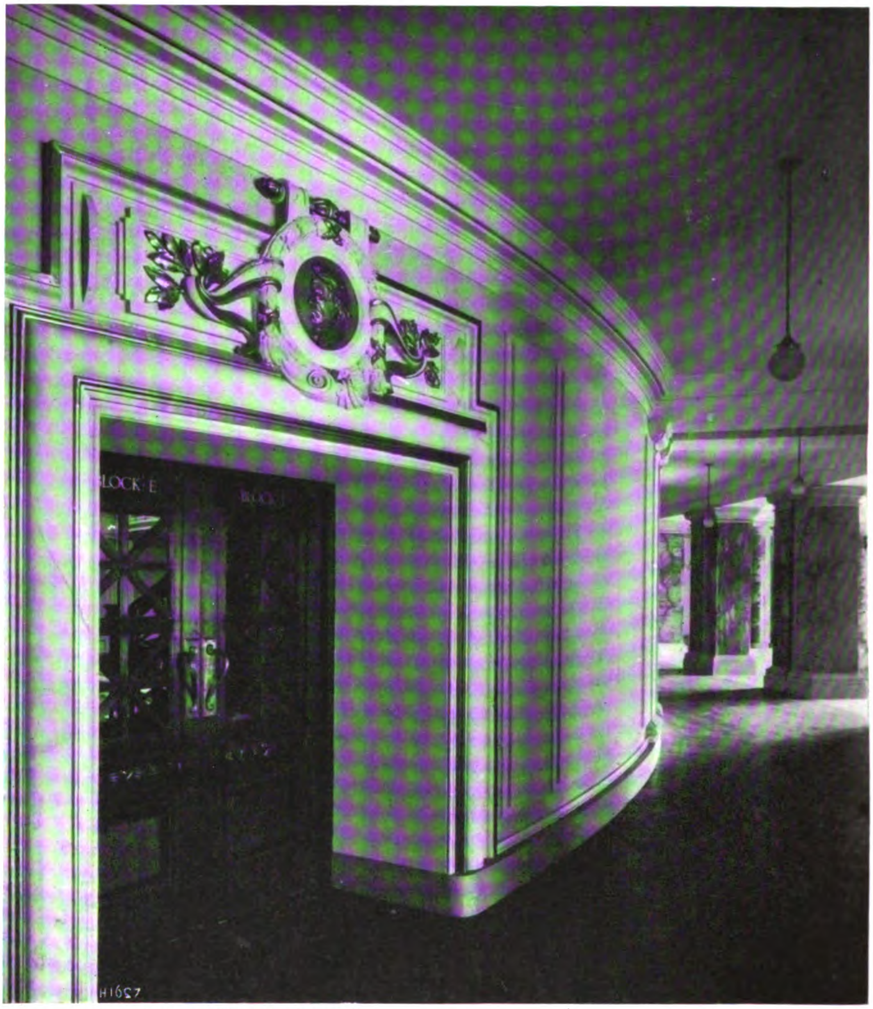
The cantilever beams are received into a continuous padstone beam 2 ft. 4½ in. in breadth by 5 ft. in depth constructed on the inner drum wall, and are "anchored" into the outer drum wall by similar padstone beams 2 ft. in breadth by 4 ft. 9 in. in depth. The cantilever beams are strutted behind the point of support on the inner drum wall by the air duct, which is formed by means of a continuous reinforced concrete floor 6 in. in thickness, the air duct having a depth of 2 ft. 8 in. and a breadth of 8 ft. 7½ in., and a lower continuous reinforced concrete floor 4 in. in thickness.

The upstand front of the gallery is constructed of reinforced concrete 4 in. in thickness curved both in the longitudinal direction following the sweep of the gallery and also vertically, and beneath the upstand front a strutting beam 6 in. broad by 8 in. deep, also following the sweep of the gallery front, is provided between the extreme points of the cantilever beams.

For further security an additional reinforced concrete strutting beam 6 in.

by 12 in. is provided between the cantilever beams at the centre of the span of the outhang of the cantilevers and at their lower edge.

The horizontal portion of the reinforced concrete degrees of the seated portion of the Grand Tier gallery is 3 in. in thickness, and the vertical breasts are 4 in. in thickness, the latter being constructed as beams and the former as floor slabs supported between these beams.



Photographer, F. C. Inglis, Edinburgh.]

Fig. 4. View of Corridor.
THE USHER HALL OF MUSIC, EDINBURGH.

The vertical breasts are also junctioned with the upper portion of the cantilever beams in a secure manner, and serve as struts between these beams.

A reference to the longitudinal section, *Fig.* 6, will show that reinforced concrete lintels were provided over the doorways giving access to the area of

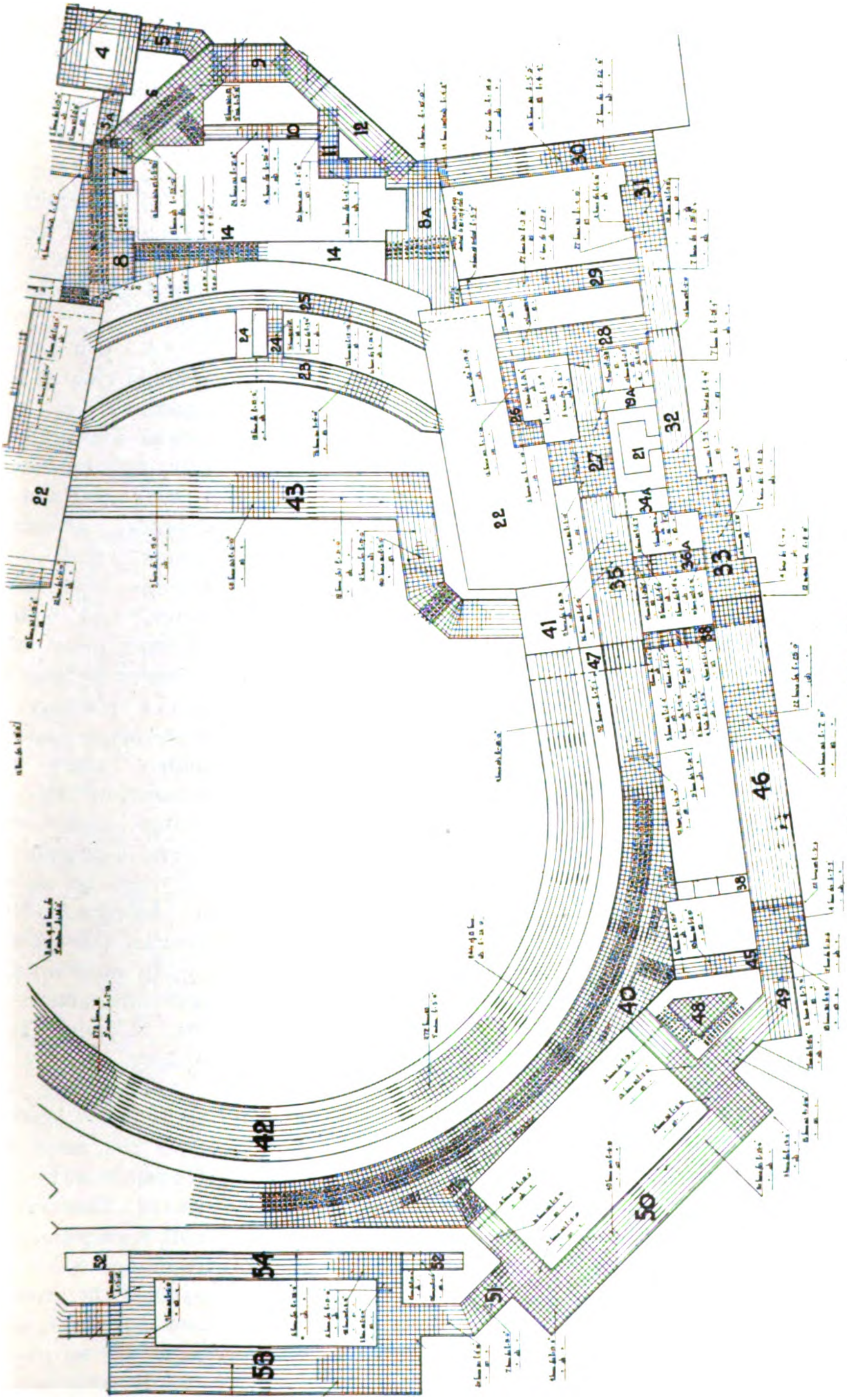


Fig. 5. Part Foundation Plan.
The Usher Hall of Music, Edinburgh.

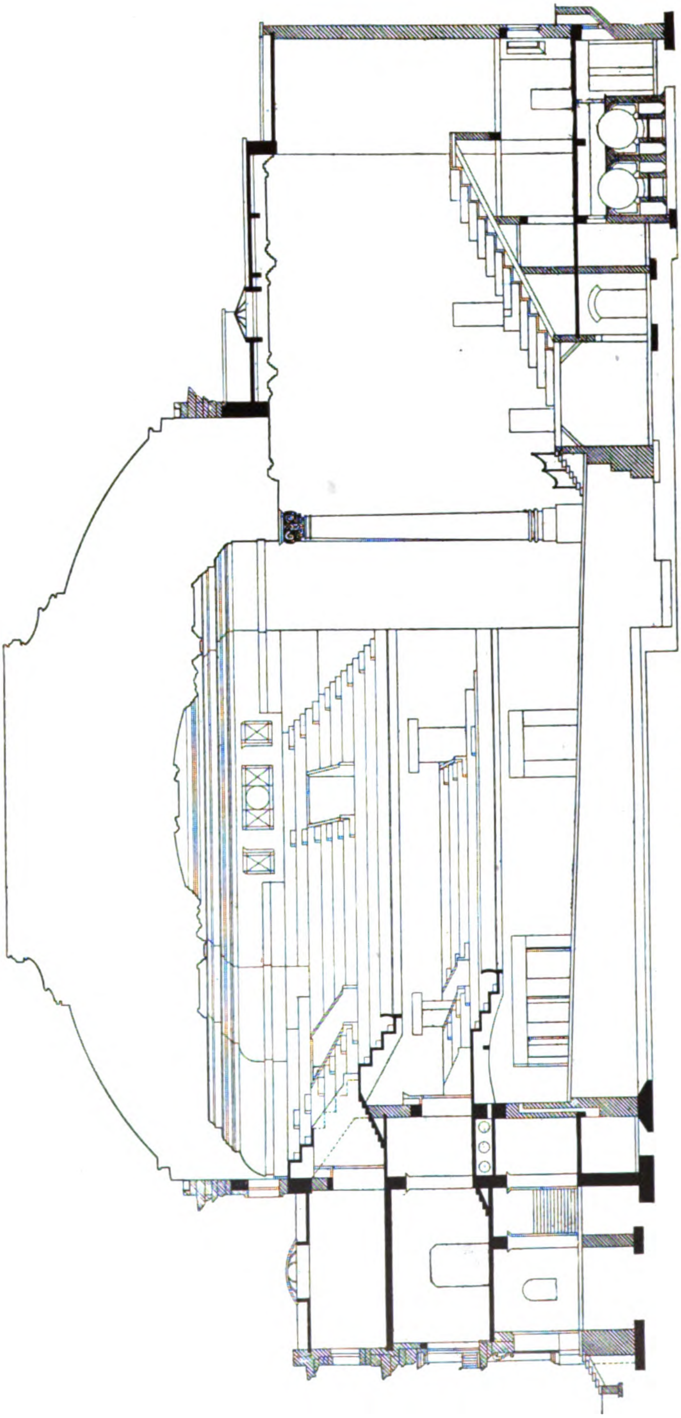


Fig. 6. Longitudinal Section.
THE USHER HALL OF MUSIC, EDINBURGH.

the auditorium, and as these lintels had to support the loading from both the Grand Tier and Upper Tier galleries, they had to be of exceptional strength. Their section is 2 ft. 3 in. broad by 3 ft. in depth.

A photographic view of the underside of the Grand Tier gallery showing the cantilever beams, degrees, strutting beams, and continuous padstone beam, and lintels on inner drum wall is shown by *Fig.* 9. This photograph was taken immediately after the removal of the centering under the Grand Tier gallery.

Fig. 10 shows a photographic view of the centering in position for the construction of the Upper Tier gallery.

There are two staircases leading from the main entrance hall to the Grand Tier crush hall, each 7 ft. 3 in. in width, and having the treads and landings constructed in reinforced concrete also covered with marble.

The Upper Tier gallery covers approximately an area of 4,400 sq. ft., and is supported by 26 reinforced concrete cantilever beams. This gallery has a maximum horizontal projection in cantilever of 13 ft. 8 in. beyond the inner drum supporting wall, being considerably less than that of the Grand Tier gallery below, but is carried back on the rake over and beyond the inner drum wall to the outer drum wall, thus affording a considerably larger seating area than on the Grand Tier.

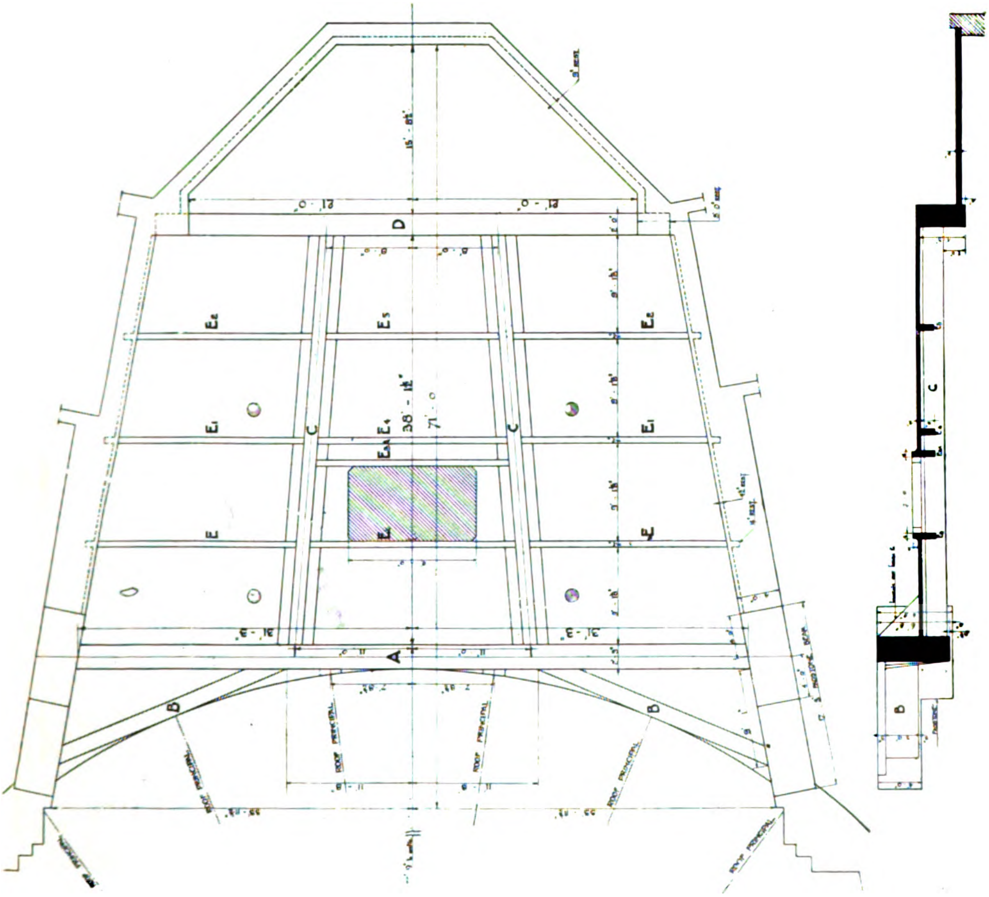


Fig. 7. **Plan and Section of Roofing over Orchestra.**
THE USHER HALL OF MUSIC, EDINBURGH.

The Upper Tier gallery cantilevers are also supported on the inner drum wall, and are anchored back into a heavy reinforced concrete continuous padstone beam in the outer drum wall, 2 ft. 3 in. by 3 ft. 9½ in.

The reinforced concrete degrees and upstand front are formed in a similar manner to those on the Grand Tier.

The horizontal landings of entrances to the Grand Tier gallery are constructed of reinforced concrete 6 in. in thickness, as also are the walls at either side of the entrances and the lofty "baffle" walls at the back of this gallery.

The stairways at the five entrance doors leading from the corridors to this gallery are also constructed in reinforced concrete.

The floors at the level of the Upper Gallery crush halls and corridors present several interesting features. Towards the ends of the corridors at either side of the hall the outer drum wall changes direction from the pear-shaped form of the auditorium to a complete circle surmounted by the main domed roof. To permit of this change of direction the wall passes across the 9 ft. corridor in a diagonal circled direction approximately 23 ft. in length, when it arrives over the heavy brick butts, built solid from beneath, at the sides of the proscenium opening.

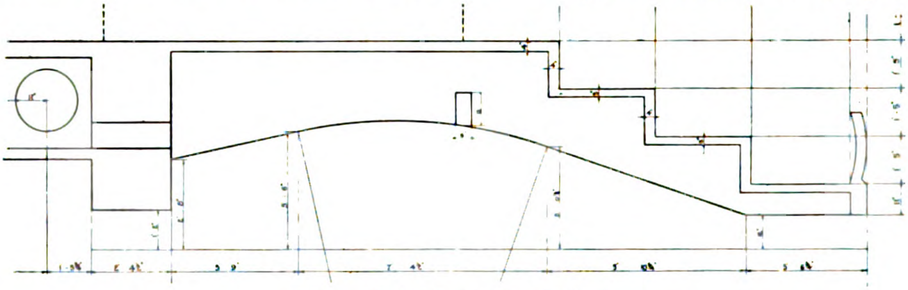


Fig. 8. Typical Grand Tier Cantilever.

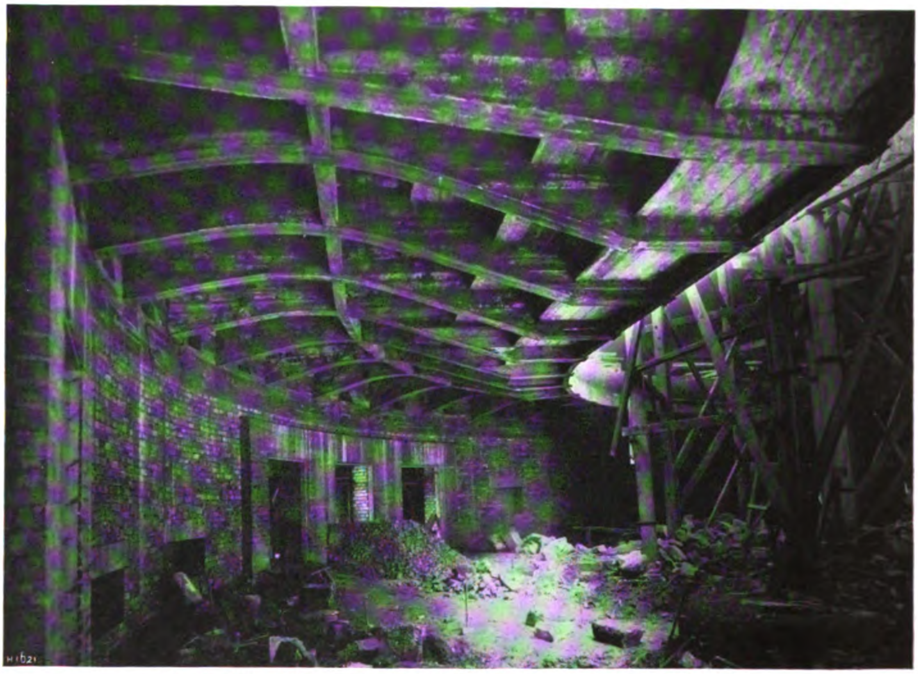


Fig. 9. View of Grand Tier Gallery from below on removal **of centering.**
THE USHER HALL OF MUSIC, EDINBURGH.

The problem presented was the support of this wall 2 ft. 3 in. thick, rising to a height of 31 ft. above the corridor floor, and of the reactions from the flat concrete and main domed roofs taking support on this wall, without unduly interfering with the headroom in the main corridor of the Grand Tier level beneath. This was effected by a special system of reinforcement in the corridor floor at Upper Tier level for a total length of 29 ft. on either side of the hall, the total depth of the reinforced concrete floor supporting the severe loading thus imposed on it being confined to 18 in., giving 13 ft. of headroom in the Grand Tier corridor below.

Further interesting features of the reinforced concrete construction at this level are the floors over the crush hall and foyers on the Grand Tier level below. These floors are formed by flat slabs 38 ft. by 23 ft. 6 in. and 12 in. in thickness without projecting beams.

The reinforced concrete roofs over the orchestra and organ present unique features, as will be seen by a reference to *Fig.* 7, showing the method of construction of these roofs in plan and also in section.

The roof over the orchestra had to be centred from the level of the basement, an average height of 60 ft.

The construction of these roofs is carried out at three different levels :—

(*a*) To auditorium side of beam A slab 9 in. in thickness, projecting partly in cantilever beyond beams A and B trained to follow the circumference of the main domed roof.

(*b*) Between beams A and D slab 4 in. in thickness, with a system of tertiary beams E, and secondary beams C.

(*c*) Over organ. Slab 6 in. in thickness. Maximum free span 15 ft. 8½ in.

It will be noted from the sectional drawing that in addition to the ends of beams A and B being stayed by the padstone beams at both supports, strong reinforced concrete gusset pieces have been introduced over beams C at their junction with beam A.

The main beam A, in addition to the reinforced concrete roofs, over a span of 62 ft. 6 in., supports the solid masonry wall of the dome to a height of 6 ft. 6 in. above the beam, along with a heavy projecting masonry cornice and four roof principals of the main domed roof.

The roofs over the gallery crush halls are all of special type, as can be seen by reference to the longitudinal section, *Fig.* 6.

These roofs are constructed with the reinforced concrete beams *above* the roof slabs, the object of this being to avoid any beaming appearing below the ceiling line.

A reference to the longitudinal section of the building (*Fig.* 6) will show that immediately below the masonry cornice of the outer drum wall a continuous reinforced concrete beam was constructed.

This beam has a depth of 2 ft. 6 in., and varies in breadth from 10½ in. to 1 ft. 6 in., and is continuous right round the complete circle of the outer drum wall supporting the main domed roof, and has therefore a total length of 370 ft.

It serves the purpose of (1) forming a complete circular tie round the dome; (2) spreading the isolated loads on the masonry from the principals of the main domed roof; and (3) forming lintel beams over the clerestory window openings into the back of the Upper Tier gallery.

In conclusion of this necessarily restricted description, it may be stated that approximately 300 tons of steel and 6,000 tons of concrete were required for the reinforced concrete constructional work.

Summary.—The interior of the hall has a very attractive aspect. Its constructive lines are pleasing and satisfactory, and it is well proportioned in respect of height, width, and depth.

The scheme of decoration of the auditorium and orchestra in white and gold also satisfies by its simplicity and refinement, and the marble and bronze work of the entrance and crush halls and foyers are in similar excellent taste.

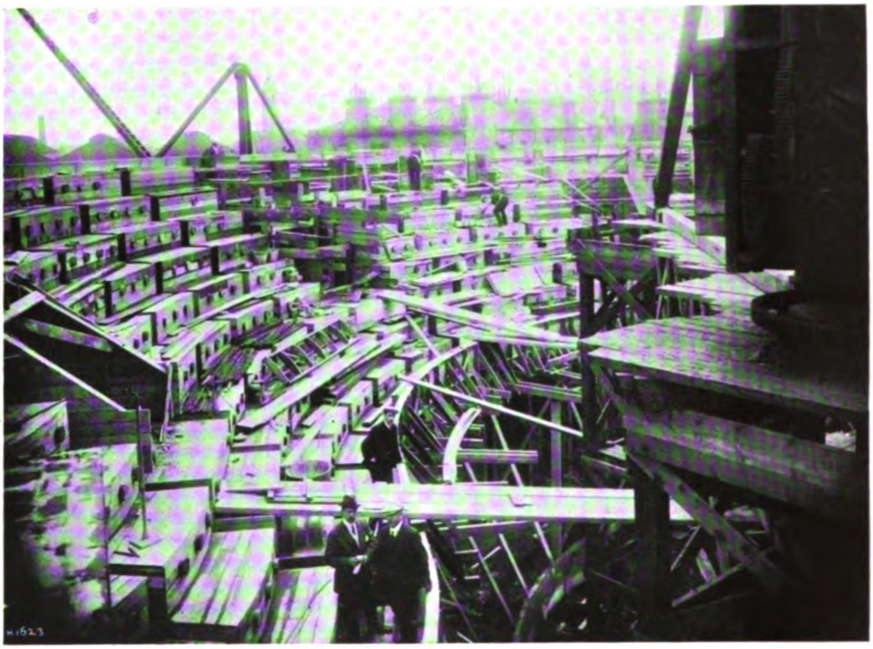
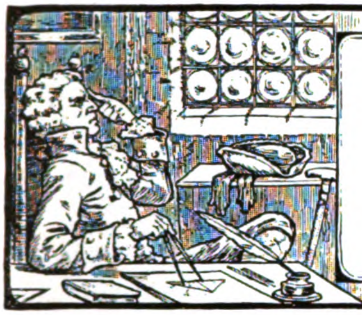


Fig. 10. Temporary Centering of Upper Tier Gallery in position.
THE USHER HALL OF MUSIC, EDINBURGH

The acoustics of the hall have been proved to be perfect, and this is to be specially noted in view of the extensive use which has been made of reinforced concrete construction.

The architects for the hall are Messrs. Stockdale Harrison and Sons, and H. H. Thomson, F.R.I.B.A., Leicester.

In the design of the reinforced concrete constructional work the architects associated with them Messrs. F. A. Macdonald and Partners, consulting engineers, 135, Wellington Street, Glasgow, and the close co-operation which has been uniformly maintained between the architects and the reinforced concrete engineers ever since the first designs were made in September, 1910, has materially helped in the elucidation of many complex structural problems.



SHEARING OR DIAGONAL TENSION REINFORCEMENT IN BEAMS.

By CHARLES F. MARSH, M.Inst.C.E.

The following article should be of special interest to engineers and others who study this important question—ED.

GENERAL OBSERVATIONS.

When longitudinal tensile reinforcements are bent up it is necessary to ascertain that the bending moment is sufficiently reduced at the point of bending to allow of the bending up of the bars.

All bent up bars should be bent over at the top and continued along the upper surface and finished with a hooked end having an internal radius of at least twice the diameter of the least side of the bar, or otherwise securely anchored. They are sometimes carried well into the portion of the beam acting in compression and finished with a hooked end, or, better still, hooked over a bar placed near the compressive surface, the hook fitting against the surface of the anchorage bar. These methods of anchorage apply also to special inclined or vertical bars. An alternative method of placing these bars is to hook their ends around the longitudinal tensile reinforcements and make them continuous through the portion of the beam under compression. This method is the reversal of the usual practice, but is advisable since it gives a good anchorage in the compressive portion of the beam.

When longitudinal tensile bars are bent up it is advisable to make the bends with as large a radius as possible in order that the compression on the concrete at the point of bending may be reduced as much as possible. The radius of curvature of the bottom bends and also the top bends, when the bars are continued near the upper surface of the beams, should be about 12 times the diameter of the least side of the bar. When vertical reinforcements or stirrups are used to resist diagonal tension, it is usual to make them of the same sectional area throughout. As these bars are numerous and have to be bent to small curvatures so as to pass closely around the longitudinals, they should not exceed $\frac{3}{8}$ in. diameter, and may well be $\frac{5}{16}$ or $\frac{1}{4}$ in. diameter, as these sizes are easier to bend.

All diagonal tensile reinforcements should be securely attached to the longitudinal bars. This is sometimes effected by indenting the longitudinals to receive the diagonal tension bars and tying the two tightly together with wire ties, but the stress on the longitudinal bars must have become sufficiently reduced to admit of the indentations. It is obvious that any form of reinforcement in which the diagonal tension bars are rigidly attached to, or are integral with, the longitudinals is greatly to be preferred.

In the design of T-beams it is advisable in every case to place vertical or inclined reinforcements throughout the whole length of the beam at distances apart not greater than the lever arm (a) of the couple resisting the bending moment.

As a consequence of this provision, the value of the resistance of the concrete itself should only be taken into account in the design of rectangular beams.

It is usual to allow a safe tensile working stress on diagonal tension reinforcements of only three-quarters that allowed for direct tension. Consequently for mild steel the limiting working stress in the steel for these reinforcements is taken as

12,000 lb. per sq. in. When reinforcement is used to resist diagonal tensile stress the resistance of the concrete must not be taken into account, as the concrete must have cracked long before the reinforcement is stressed to 12,000 lb., although the cracks are unnoticeable and too fine to be detrimental.

INCLINED OR BENT-UP BARS.

The difference of the longitudinal tensile stress (where B_1 is the greater bending moment, at one extremity of the length l_s, and B_2 is the lesser bending moment, at the other extremity of the length l_s) will be $\frac{B_1 - B_2}{a} = \frac{S}{a} = \frac{S_m l_s}{a}$* where S_m is the mean shearing force on the length l_s and a is the lever arm of the resisting couple.

When the increment in the stress in the tensile reinforcement over any length l_s is to be taken by inclined reinforcements or bent-up bars in tension and by the concrete of the beam in compression, one-half of this increment in the stress may be considered as being resisted by the concrete in compression on such lines as those parallel to *a d* and *c f* (*Fig.* 1) cutting the longitudinal tensile reinforcement and one-half by the reinforcement in tension on such lines as *c b* and *e d* (*Fig.* 1). The stresses on the verticals, such as *c d* and *e f*, balancing one another.

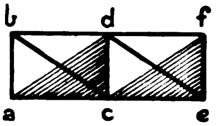


FIG.1.

It is to be noted that this will not be true when the lines such as *a d*, *c b*, *e f*, and *e d* have flat slopes, since in such a case the concrete in compression would be over stressed, and consequently we must assume that

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* Proof that $B_1 - B_2 = S$ is as follows:—

If we consider a length of a beam to the left of the centre between a section (X) at a distance of (x) from the left support and a section (Y) at a distance of (y) from the left support, and use the following symbols—

R_L = reaction at left support,
W = any loads to the left of section (X),
W_1 = any loads between the sections (X) and (Y),
(The W's and W_1's being of any intensity.)
z = the distances of the loads (W) from the section (X),
and z_1 = the distances of the loads (W_1) from the section (Y),
We have for the shearing force at section (X)—

$$S_1 = R_L - \Sigma W.$$

The mean value of the *decrease* of the shearing force on the length $(y-x)$ between the sections (X) and (Y) will be—

$$\frac{\Sigma(W_1 z_1)}{(y-x)}.$$

We have therefore for the mean value of the total shearing force on the length $(y--x)$ between the sections (X) and (Y)—

$$S_m = R_L - \Sigma W - \frac{\Sigma(W_1 z_1)}{(y-x)}.$$

The total shearing force on the length $(y-x)$ will therefore be—

$$S = R_L(y-x) - \Sigma\left\{ W(y-x) \right\} - \Sigma(W_1 z_1).$$

The bending moment at section (X) will be—

$$B_2 = R_L x - \Sigma(Wz).$$

And the bending moment at section (Y) will be—

$$B_1 = R_L y - \Sigma(Wz) - \Sigma\left\{ W(y-x) \right\} - \Sigma(W_1 z_1),$$

and the increase of the bending moment over the length $(y--x)$ will be—

$$B_1 - B_2 = R_L(y-x) - \Sigma\left\{ W(y-x) \right\} - \Sigma(W_1 z_1) = S.$$

if the reinforcements on lines such as *c b* and *e d* have a lesser slope to the horizontal than some limiting angle they must be calculated as resisting more than one-half the stress of $\frac{B_1 - B_2}{a}$ or $\frac{S_m l_s}{a}$. We will therefore assume that for angles less than 45° to the horizontal the reinforcements will resist a gradually increasing proportion of the stress until an angle of say 25° is reached, at which they must be assumed as resisting the whole of the stress. Diagram *Fig.* 2 gives the reciprocals of the proportion of the total stress which must be taken up by the inclined reinforcements for angles between 45° and 25° to the horizontal; for angles less than 25° the reinforcements must be assumed to take up the whole of the stress.

Since the increment of stress in the longitudinal tensile reinforcement over a length l_s is $\frac{S_m l_s}{a}$, we therefore get—

$$A_s t \operatorname{Cos} \theta = \frac{S_m l_s}{a} \times q \text{ (See } Fig. \text{ 3)}$$

$$\text{or } S_m = \frac{1}{q} \cdot \frac{a}{l_s} \operatorname{Cos} \theta \, . \, A_s t. \qquad (1)$$

Where A_s is the sectional area of the inclined bar t is the safe tensile resistance of the steel to diagonal tension, θ is the angle of the inclined bar to the horizontal, and q is the proportion of the stress taken by the reinforcement. Where the reinforcement makes an angle with the horizontal of 45° or over $\frac{1}{q}$ has a value of 2, and for flatter angles it has the values given in *Fig.* 2.

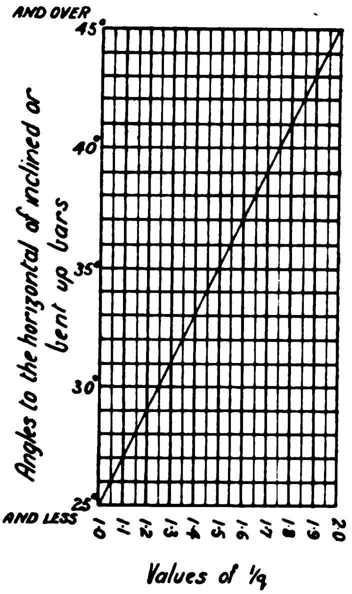

FIG 2.

The horizontal projection of the bent-up or inclined bar between the points where it intersects the axis of the tensile reinforcement and the centre of the compressive resistance must be equal to l_s, and consequently when $\theta = 45^\circ$ $l_s = a$

$$\text{and } S_m = 2 \times 0{\cdot}707 \, A_s t = 1{\cdot}414 \, A_s t \qquad (2)$$

and in all cases

$$l_s = a \operatorname{Cot} \theta = a \frac{\operatorname{Cos} \theta}{\operatorname{Sin} \theta}$$

$$\text{and } S_m = \frac{1}{q} \cdot \frac{a \, . \, A_s t \operatorname{Cos} \theta \operatorname{Sin} \theta}{a \operatorname{Cos} \theta} = \frac{1}{q} . \, A_s t \operatorname{Sin} \theta \qquad (3)$$

VERTICAL REINFORCEMENTS OR STIRRUPS.

In the case of vertical reinforcements resisting diagonal tension we must consider the beam as having a web of the N-braced type (*Fig.* 4), with diagonals sloping upwards away from the support, such diagonals being under compressive stress. This bracing is replaced in the beam by the fibres of concrete cutting the longitudinal tensile reinforcement and parallel to the slope of the imaginary diagonals.

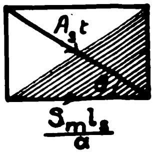

FIG. 3.

These fibres, together with the vertical reinforcements, take up the increment of stress in the tensile reinforcement or

$$\frac{B_1 - B_2}{a} = \frac{S_m l_s}{a}^*.$$

The stress on the vertical reinforcements will therefore be

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* See note p. 308.

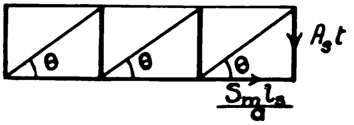


Fig 4.

$$A_s t = \frac{S_m l_s}{a} \operatorname{Tan} \theta,$$

but $\frac{l_s}{a} = \operatorname{Cot} \theta$ and $\therefore A_s t = S_m$ (4)

This stress is, of course, the same as would occur in the verticals of an N-braced girder, as shown by *Figs*. 5 and 6.

If the sets of stirrups are placed at equal distances apart their sectional area must consequently vary in an arithmetical series of 1, 3, 5, 7, 9, etc.

It is generally desirable, however, for the sets of stirrups to be of equal sectional area throughout.

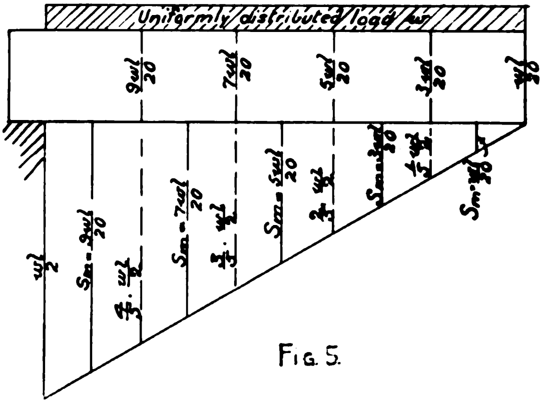


Fig. 5.

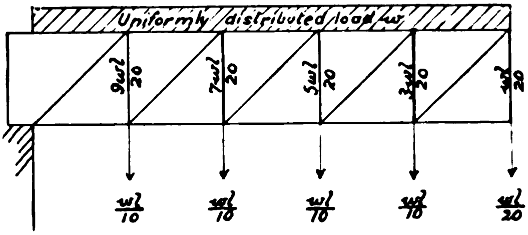


Fig. 6.

It will be seen from *Fig*. 4 that a set of stirrups having a tensile resistance of $A_s t = S_m$ resist a total longitudinal tensile stress of $\frac{B_1 - B_2}{a}$ or $\frac{S_m l_s}{a}$.

If, therefore, we reduce or increase the value of $\frac{S_m l_s}{a}$, we must reduce or increase $A_s t$ in same ratio, or $A_s t$ must vary as $\frac{S_m l_s}{a}$

But as $A_s t$ is to have a constant value if S_m increases or decreases $\frac{l_s}{a}$ must vary inversely as S_m.

Therefore for any value of S_m $A_s t$ must $= \frac{S_m l_s}{a}$ where the value of S_m varies inversely as the value of $\frac{l_s}{a}$

But in any beam a will be constant, therefore $aA_s t = S_m l_s$ (11) Where S_m and l_s vary inversely as one another, or if we make $aA_s t$ constant $S_m l_s$ must be constant and equal to $aA_s t$.

But $S_m l_s$ is the area of the shearing force diagram on the length l_s, l_s being the pitch of the stirrups.

We can therefore calculate the value of $aA_s t$ for any beam and any area of stirrups and divide up the shearing force diagram into areas equal to $aA_s t$. and the limiting verticals of such areas will give the spacing of the stirrups.

Table I. gives the values of $A_s t$ for various diameter round and square bars with various numbers of double branches, which may be multiplied by the value of a for any particular beam.

If the load is uniformly distributed the shearing force diagram for the half-span will be a triangle such a *A, B, C, Fig*. 7. The value of $A_s t$ for the set of stirrups selected can be obtained from Table I.

For the first set of stirrups (*i.e.*, those at the centre of the beam) the value of S_m must be equal to $A_s t$.

TABLE I.

	Rounds.					Squares.				
	$\frac{\text{Resistance of stirrups}}{a}$ for various numbers of branches.					$\frac{\text{Resistance of stirrups}}{a}$ for various numbers of branches.				
Branches	2	4	6	8	10	2	4	6	8	10
Diameter or side of bar.										
$\frac{1}{8}$	296	593	889	1186	1482	375	650	1025	1300	1675
$\frac{3}{16}$	695	1390	2085	2780	3475	885	1770	2655	3540	4425
$\frac{1}{4}$	1176	2352	3528	4704	5880	1512	3024	4536	6048	7556
$\frac{5}{16}$	1836	3672	5508	7344	9180	2352	4704	7056	9408	11760
$\frac{3}{8}$	2652	5304	7956	10608	13260	3384	6768	10152	13536	16920

NOTE.—These values are calculated for a safe working tensile stress of 12,000 lbs. per sq. in. If any other stress is used they must be altered proportionately.

Making the value of S_m for the portion of the shearing force diagram at the apex$=A_s t$. it will be seen from *Fig.* 7 that the length from the centre of the span to the second set of stirrups$=l_s=2.S_m\frac{AC}{AB}=S_m\frac{\text{span}}{\text{reaction at support.}}$

Lay off this distance $l_s=CD$ from the centre of the span (C) and erect a perpendicular cutting the beam this will give the position of the second set of stirrups from the centre of the span.

Now describe a semi-circle on AC.

From C as centre with CD as radius describe an arc cutting the semi-circle at $E_{\prime}$ draw $E_{\prime}E$ vertical cutting AC at E.

Set off along CA distances $EF \cdot FG \cdot GH \cdot HJ \cdot$ etc., all equal to CE and draw verticals $FF_{\prime}$ $GG_{\prime}$ $HH_{\prime}$ $JJ_{\prime}$ etc., cutting the semi-circle at $F_{\prime}$ $G_{\prime}$ $H_{\prime}$ $J_{\prime}$ etc.

With C as centre and $CF_{\prime}$ $CG_{\prime}$ $CH_{\prime}$ $CJ_{\prime}$ etc., as radii draw arcs cutting CA at $G_{\prime\prime}$ $H_{\prime\prime}$ $I_{\prime\prime}$ $J_{\prime\prime}$ etc., verticals from $F_{\prime\prime}$ $G_{\prime\prime}$ $H_{\prime\prime}$ $J_{\prime\prime}$, etc., will divide the triangle ABC into areas all equal to CDK, and these verticals produced through the beam are the positions where sets of stirrups are to be placed.

If the resistance of the concrete is to be taken into consideration we must find this resistance and set up a vertical ordinate equal to its values on the diagram of shearing forces, and omit all the sets of stirrups between this ordinate and the point of no shear on the beam except the set nearest the ordinate.

In the case taken for the example (*Fig.* 7) the span of the beam was 16 ft., the uniformly distributed load 4,000 lb. per foot run, the width of the beam 10 in., and the effective depth 24 in. The reinforcement was stressed at 16,000 lb. per sq. in., and the maximum stress on the concrete was 600 lb. per sq. in. The value of the lever arm was therefore 24 × 0·88, and the resistance of the concrete of the beam to diagonal tension was therefore $60 \times 10 \times (24 \times 0{\cdot}88) = 12{,}672$ lb.

Consequently the sets of stirrups on the verticals from D and $F_{\prime\prime}$ would be omitted if the resistance of the concrete was taken into account.

The following example shows a method which may be adopted in calculating the resistance to diagonal tension in more complicated cases, and when inclined bars are used as well as stirrups.

Example.—A T-beam span 18 ft. loaded with 16,450 lb. from a column at the centre of the span, and also two loads 6 ft. from either support of 12,730 lb. from secondary beams. Thickness of slab 4 in. Beams continuing over several supports. Assume depth of rib to be 20 in. and width 18 in., weight = 200 lb. per lin. ft.

$B = 1{,}207{,}236$ in. lbs. approximately:

width of flange acting with T-beam $= 15 \times 4 = 60$ in. $\frac{B}{b} = 21{,}120$ giving $d = 17$ and $A_t = 6{\cdot}72$ sq. ins., or, say, 3—1⅛ in. rods in top layer and 3—1¼ in. rods bottom layer. The depth of the rib will be 17 in., weighing 180 lbs.

The reactions at the supports are $\frac{16{,}450 + 25{,}460 + 3{,}640}{2} = 22{,}575$ lbs., and the

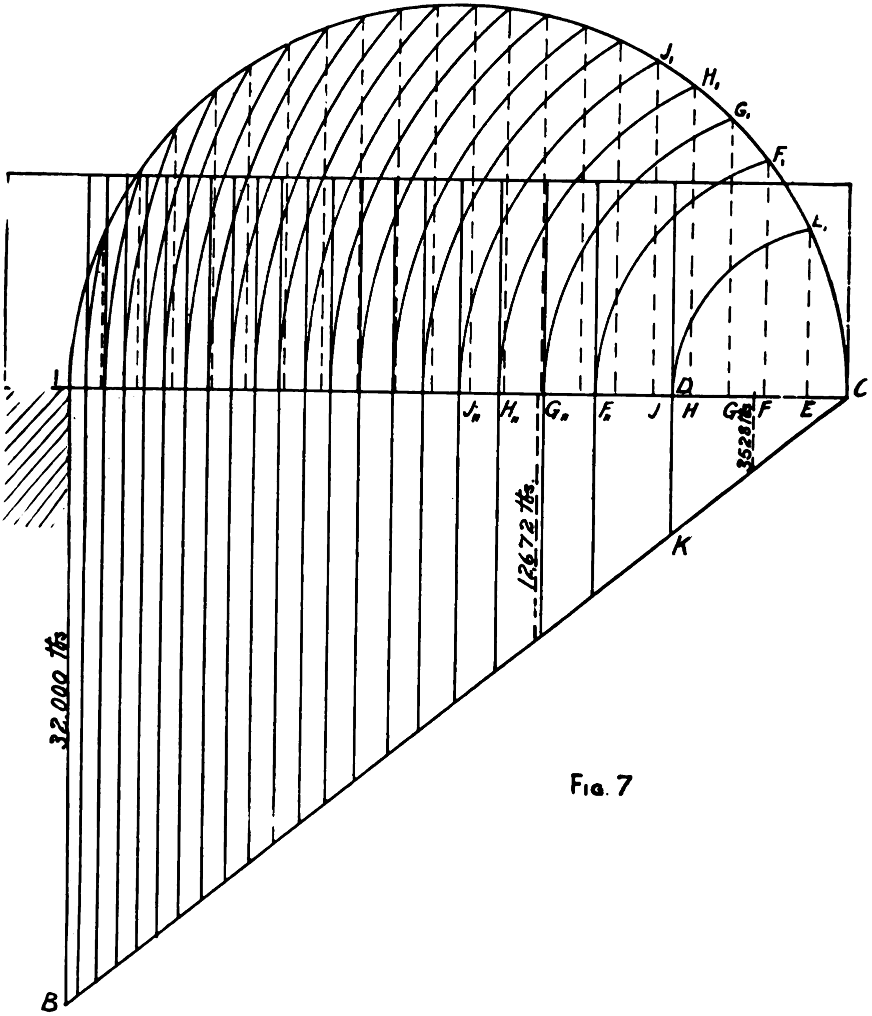


Fig. 7

shearing face diagram will be as shown in *Fig.* 8. As the shearing force diagram is the same on both sides of the centre of the span we need only use the left half.

In *Fig.* 8 draw the half-elevation of the beam to any scale and plot the shearing force diagram to scale below the horizontal line indicating the bottom of the beam.

A sufficiently accurate approximation for the lever arm for a T-beam is $a = d - \frac{d_s}{2}$.

and therefore in this case $a = 17 - \frac{4}{2} = 15$ in

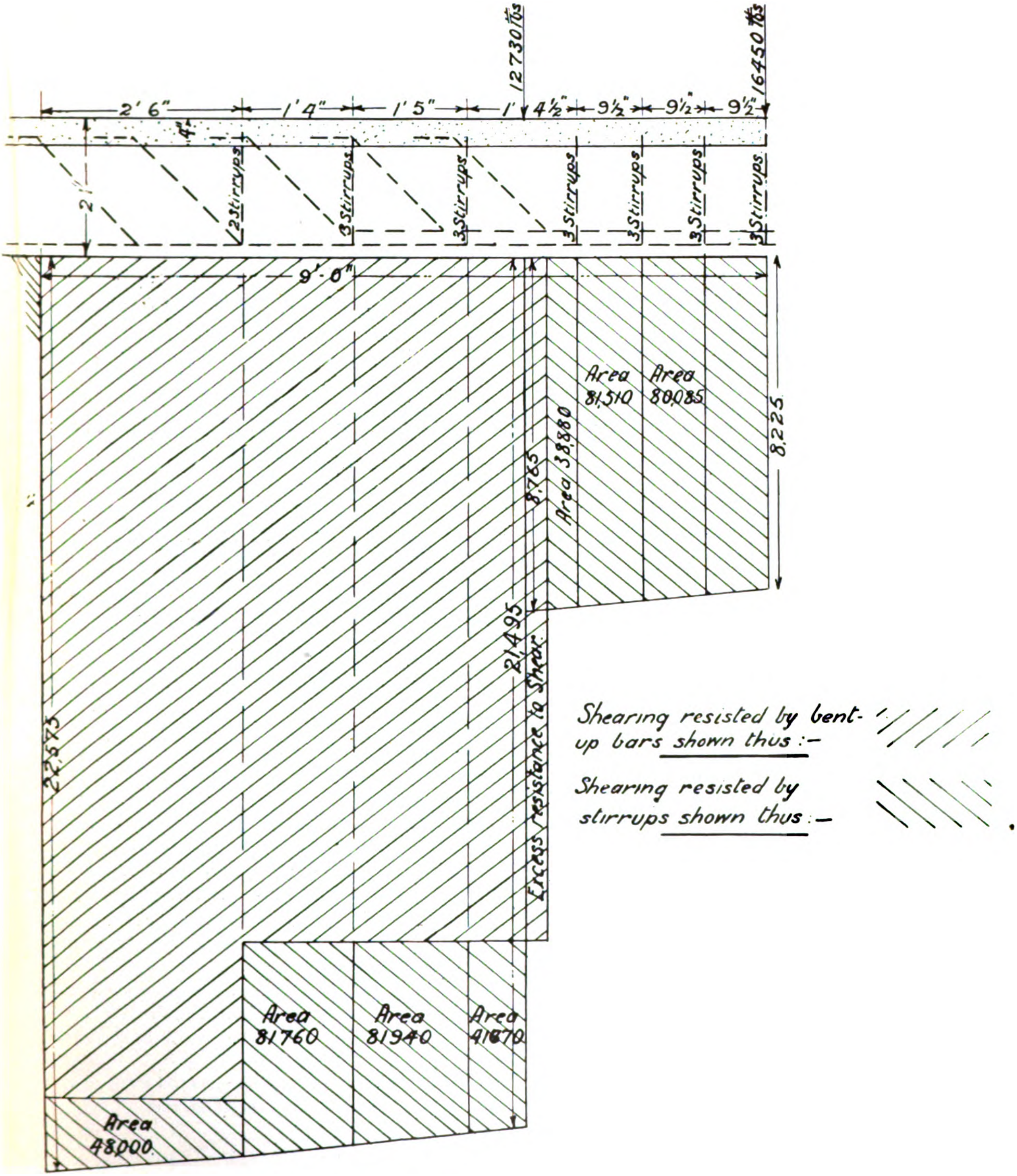

12730 lbs
16450 lbs
2' 6"
1' 4"
1' 5"
1'
4½"
9½"
9½"
9½"
4"
2' 1"
2 Stirrups
3 Stirrups
3 Stirrups
3 Stirrups
3 Stirrups
3 Stirrups
3 Stirrups
9'-0"
Area 81,510
Area 80,085
Area 38,880
8,225
8,765
21,495
22,573
Excess resistance to Shear
Area 81760
Area 81940
Area 41670
Area 48000
Shearing resisted by bent-up bars shown thus :-
Shearing resisted by stirrups shown thus :-

Fig. 8.

If we bend up a bar of the tensile reinforcement 15 in. from the support, and others 30 in., 45 in., 60 in., and 75 in. from the support.

The bending moment at *75* in. from the support will be approximately

$$\tfrac{2}{3}(22{,}575\times75-180\times6\cdot25\times37\cdot5-12.730\times3)=\tfrac{2}{3}\{1{,}693{,}125-(42{,}187+38{,}190)\}$$
$$=1{,}075{,}165 \text{ in. lbs.},$$

and assuming the lever arm as 15 in. the sectional area of the tensile reinforcement required will be

$$A_t=\frac{1{,}075{,}165}{16{,}000\times15}=4\cdot48 \text{ sq. in.}$$

The bending moment at *60* in. from the support will be approximately

$$\tfrac{2}{3}(22{,}575\times60-180\times5\times30)=(1{,}354{,}500-27{,}000)\tfrac{2}{3}=1{,}327{,}500\times\tfrac{2}{3}=885{,}000$$

and assuming the lever arm as 15 in. the sectional area of tensile reinforcement required will be

$$A_t=\frac{885{,}000}{16{,}000\times15}=3\cdot686 \text{ sq. in.}$$

The bending moment at *45* in. from the support will be approximately

$$\tfrac{2}{3}(22{,}575\times45-180\times3\cdot75\times22\cdot5)=\tfrac{2}{3}(1{,}015{,}875-15{,}187)=1{,}000{,}688\times\tfrac{2}{3}=666{,}125 \text{ in. lbs.}$$

and

$$A_t=\frac{666{,}125}{16{,}000\times15}=2\cdot775 \text{ sq. in.}$$

The bending moment at *30* in. from the support will be approximately

$$\tfrac{2}{3}(22{,}575\times30-180\times2\cdot5\times15)=\tfrac{2}{3}(677{,}250-6{,}750)=\tfrac{2}{3}(670{,}500)\ 447{,}000 \text{ in. lbs.}$$

and

$$A_t=\frac{447{,}000}{16{,}000\times15}=1\cdot82 \text{ sq. in.}$$

The bending moment at *15* in. from the support will be approximately

$$\tfrac{2}{3}(22{,}575\times15-180\times1\cdot25\times0\cdot625)=\tfrac{2}{3}(336{,}938)=224{,}625 \text{ in. lbs.}$$

and

$$A_t=\frac{224{,}625}{16{,}000\times15}=0\cdot933 \text{ sq. in.}$$

If we bend up 1—1⅛-in. rod at 75 in. from the support, 1—1⅛ at 60 in., 1—1⅛ at 45 in., 1—1¼ at 30 in., and 1—1¼ at 15 in. from the support we have

5·665 sq. in. tensile reinforcement at 75 in. from the support, one outer 1⅛-in. rod being bent up.
4·667 sq. in. at 60 in. from the support, the central 1⅛-in. rod being bent up.
3·669 sq. in. at 45 in. from the support, the other outer 1⅛-in. rod being bent up
2·442 sq. in. at 30 in. from the support, one outer 1¼-in. rod being bent up.
1·215 sq. in. at 15 in. from the support, the other outer 1¼-in. rod being bent up.

These areas will give ample resistance in all cases. The rods will be bent up at angles of 45°, *special care being taken to form the bends with flat curves, in order that the compression on the concrete at the bends may be reduced as much as possible. The radius of curvature for the bottom bends and top bends, if the bars are to be continued near the surface of the beams, should be about twelve times the diameter of the bar.*

The sectional area of 1—1⅛-in. rod is 0·994 sq. in. and that of 1—1¼-in. rod is 1·227 sq. in.

And as the distance apart of the bent-up rods has been made equal to the lever arm we have from equation (2) the shearing force resisted by each of the 1⅛-in. rods

$$S_m=1\cdot414\times12{,}000\times0\cdot994=16{,}866 \text{ lbs.}$$

and the shearing forces resisted by each of the 1¼-in. rods

$$S_m=1\cdot414\times12{,}000\times1\cdot227=20{,}720 \text{ lbs.}$$

Now draw a horizontal line on the shearing force diagram at a distance below the bottom of the beam of 20,720 lb. to the scale of loads and for a distance of 2½ ft. from the support, and another horizontal line at a distance of 16,866 lb. to the scale of loads from 2½ ft. to 6¼ ft. from the support. The area of the shearing force diagram enclosed by these lines indicates the shear resisted by the bent-up bars, and the portion not enclosed indicates the shear remaining and which must be resisted by further reinforcements. These portions of the shear will be taken by vertical stirrups, and as diagonal tension reinforcements must be placed throughout the entire span at no greater distance apart than the length of the lever arm, the spacing of the stirrups must not exceed this length on the portion between the section 6¼ ft. from the support and the centre of the span.

Now if we use $\frac{5}{16}$-in. diameter bars for the stirrups, each stirrup having two branches, from Table I., and with a value of $a = 15$ we get

For two branches $aA_st = 1{,}836 \times 15 = 27{,}540$ lbs.
„ four „ $aA_st = 3{,}672 \times 15 = 55{,}080$ „
„ six „ $aA_st = 5.508 \times 15 = 82{,}620$ „

The mean shearing force on the remaining portion of the shearing force diagram for a distance of 2½ ft. from the support as scaled is 1,600 lb., and the area of this portion of the diagram is therefore $1{,}600 \times 30 = 48{,}000$ lb.

We must therefore insert two stirrups at a distance of 2½ ft. from the support.

By trial and error we find that portion of the diagram between 2½ ft. and 3 ft. 10 in. from the support = 81,760 lb.

Three stirrups will therefore be placed 3 ft. 10 in. from the support. Similarly the area of the portion of the diagram between 3 ft. 10 in. and 5 ft. 3 in. from the support = 81,940 lb.

Three stirrups will therefore be placed 5 ft. 3 in. from the supports.

The central ordinate of the remaining portion of the diagram up to the load of 12,730 lb. at 6 ft. from the supports is 4,630. The area therefore is $4{,}630 \times 9 = 41{,}670$ lb.

The remaining shear to be resisted by the three stirrups will be $82{,}080 - 41{,}670 = 40{,}410$ lb.

The shear between 6 ft. from the supports and the section 6¼ ft. from the support where the first bar is bent up is resisted by the bent-up bar, therefore an area of the shearing force diagram of 40,410 is required between a section 6¼ ft. from the support and the centre of the span.

The area of the portion between 6¼ ft. and 6 ft. 7½ in. from the support is 38,880 lb

Three stirrups will therefore be placed 6 ft. 7½ in. from the support.

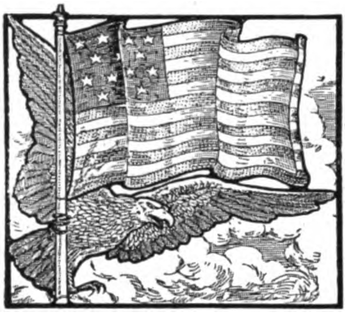
The area of the portion of the diagram between 6 ft. 7½ in. and 7 ft. 5 in. from the support = 81,510 lb.

Three stirrups will be placed 7 ft. 5 in. from the support.

The area of the portion of the diagram between 7 ft. 5 in. and 8 ft. 2½ in. from the support = 80,085 lb.

Three stirrups will be placed 8 ft. 2½ in. from the support.

A further three stirrups will be placed at the centre of the span.



REINFORCED CONCRETE VIADUCT, MARTIN'S CREEK, U.S.A.

The following particulars and illustrations of this viaduct now nearing completion have been taken from the "Engineering Record."—ED.

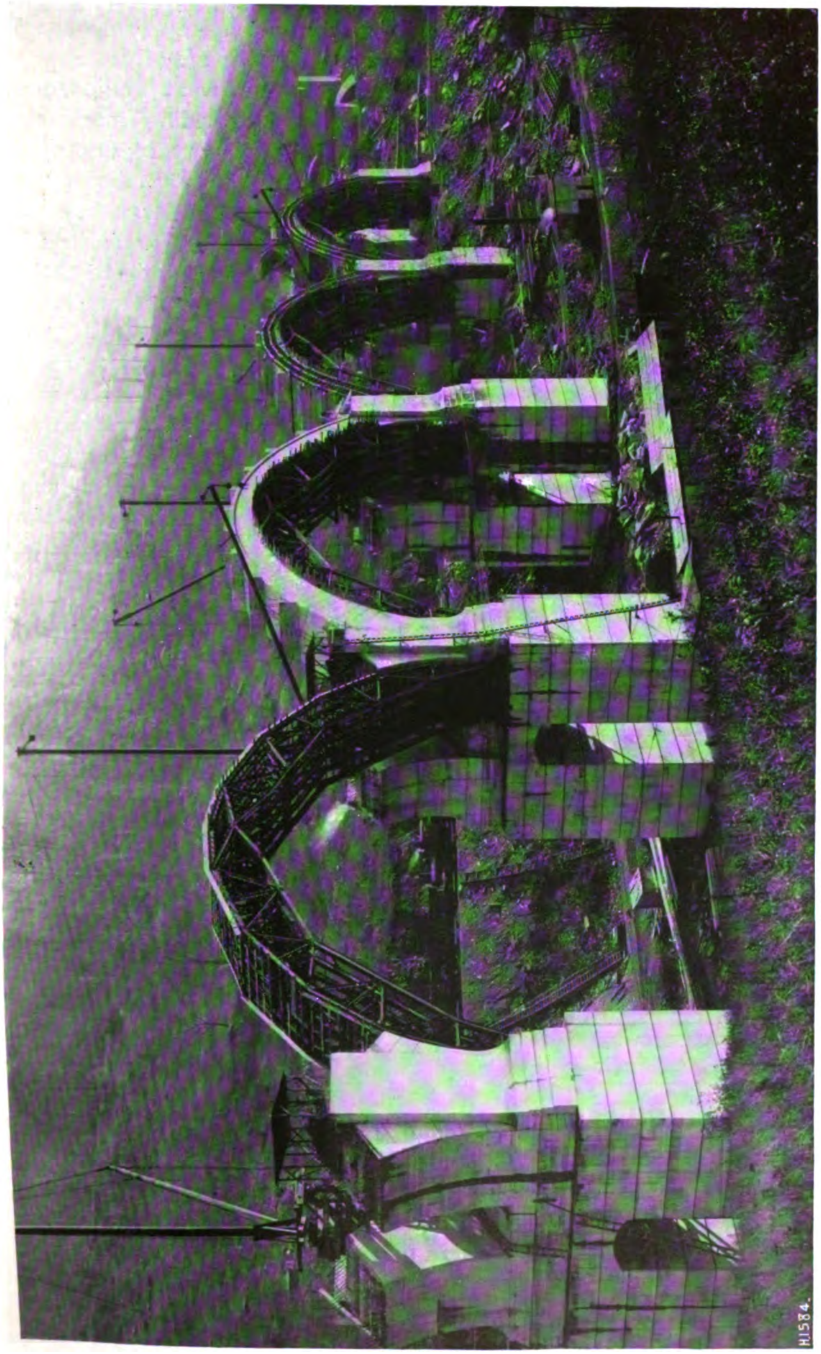
NEXT to the Tunkhannock viaduct the Martin's Creek viaduct is the most important structure in the 40-mile relocation of the main line tracks of the Delaware, Lackawanna and Western Railroad between Clark Summit and Halstead, Pa. It is built entirely of concrete, with long and lofty spans on deep foundations, carried to solid rock through beds of clay and boulders.

General Description.—The viaduct is a three-tack structure, 1,611 ft. 8 in. long and 150 ft. high above the creek. It will be 48 ft. 4 in. wide over all at the arch rings, and will have two full-centred spans of 50 ft., two of 100 ft., and seven three-centred spans of 150 ft., with a rise of 59 ft.

Each span will have two arch ribs 12 ft. apart in the clear. For the 150-ft. spans these ribs will have a width of 17½ ft. and a thickness at the crown of 6 ft. and will each contain 1,000 yds. of 1 : 3 : 5 concrete. They will carry solid transverse spandrel walls 12½ ft. apart supporting floor arches and parapet walls. The west end span is made of two-arch ring segments of 100-ft. span, forming an abutment. The concrete floor system is carried to the centre or crown of the abutment arch, with the adjacent fill extending to the end of the floor; the toe of the slope extends to the centre of the westerly 150-ft. span, the 100-ft. arch being entirely covered by the embankment. The east half of the westerly 100-ft. span carrying the bridge floor is enclosed on both sides, with spandrel walls reaching to the surface of the slope and giving the appearance of a solid masonry abutment. At the land end of this span the tracks are laid on the fill.

The completed structure will contain about 84,000 yds. of concrete and will involve about 25,000 yds. of foundation excavation.

Delivery of Materials.—Work was commenced in June, 1912, and a side track for material was connected with the main line. An additional track was also built parallel to the side track, partly supported on a wooden trestle, to provide for receiving, unloading, and storing cars. From 400 to 500 cars of material are received monthly, and about 8,000 yds. of broken stone, 4,000 yds. of sand, and 4,000 barrels of cement are kept in storage. Sand and stone are dumped into heaps on the side-hill and are thence delivered by a Mead-Morrison clamshell bucket to storage hoppers at the concrete-mixing plant. At the mixing plant a 2-yd. Carlin cubical mixer is mounted about 10 ft. above the track. From it concrete is discharged into buckets and delivered over the service tracks to the work.



First position of Arch Rib Centres and first Ring Constructed.
REINFORCED CONCRETE VIADUCT, MARTIN'S CREEK, U.S.A

Concrete is distributed to the pier sites by a 3-ft. gauge surface track which runs the full length of the viaduct and serves the power plant, shops and storage yards. There are in all eight switches, all of which are visible at a central point, where they are operated from an interlocking stand by one man, thus effecting a considerable saving of time and increasing the safety.

Sawmill.—An important part of the plant is the sawmill, equipped with a ripsaw, bandsaw, cut-off saw, planing mill, and moulding machine, all operated by one 25-h.p. and one 15-h.p. engine. Besides cutting and planing timber and doing miscellaneous work, the sawmill is of great importance in sawing the heavy timber into boards. For this contract a large amount of 12-in. by 12-in. yellow-pine timber was ordered, and most of it was first used for the construction of towers, trestles, and for the heavy bracing in the deep foundation pits. As fast as released the timber is sawed up into smaller sizes and boards and is planed for use in the construction of concrete forms.

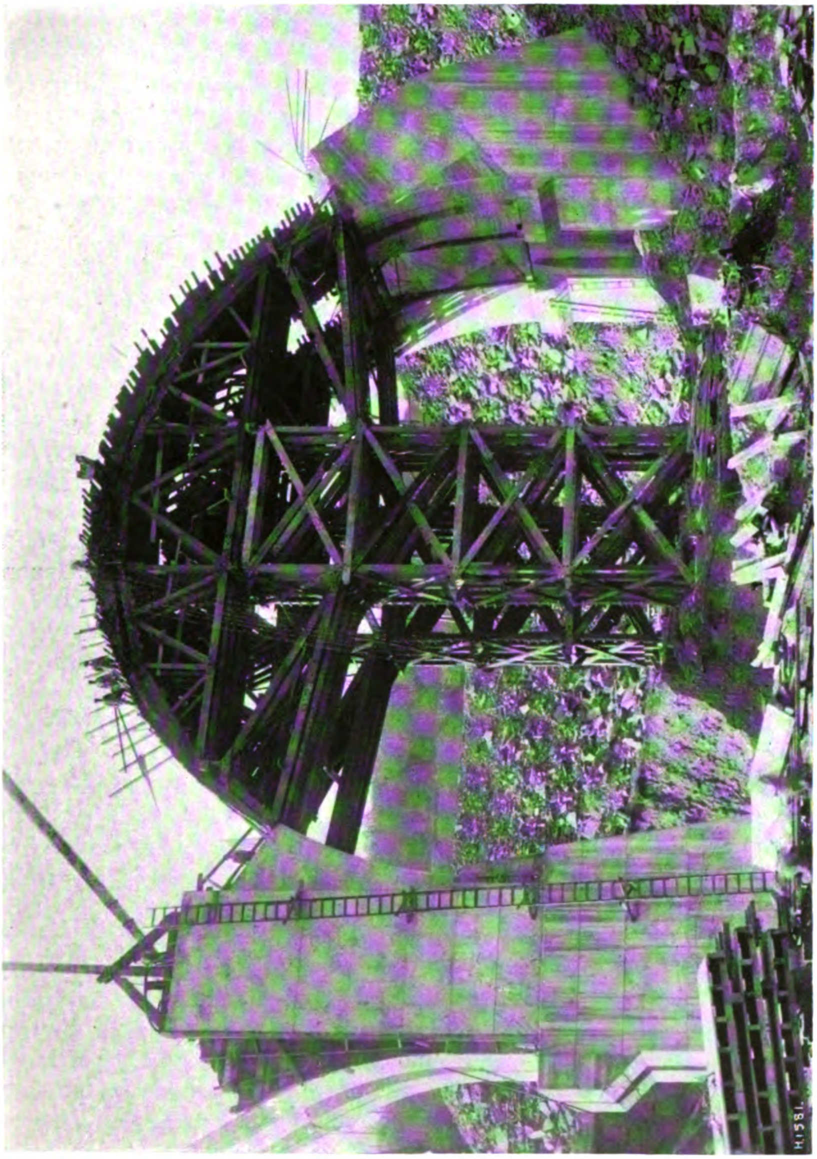
Pier Foundations.—About 30,000 yds. of earth were excavated at and near the pier site by a Marion steam shovel, which made a cut with an average depth of about 20 ft. parallel to the axis of the viaduct. The spoil was used to form embankments for the service tracks and to make a fill, on which the machine shop and concrete plants were located. The soil consists chiefly of compact water-bearing sand containing many small boulders and considerable gravel, and overlies hard blue flagstone at a depth of from 18 to 70 ft. below the surface.

The pier foundations were excavated to sound rock in open cofferdams made by driving one or two tiers of steel sheet piling with a No. 2 Vulcan steam hammer operated in 40-ft. leads suspended from a derrick boom. Where two tiers of sheeting were required the inner tier was driven first and the outer tier was driven afterward at a 5-ft. distance in order to allow clearance for excavating the earth between them.

Sheeting, Draining and Concreting.—About $10,000 worth of steel sheeting was required for the work, and some of it has been pulled and redriven four or five times, and endures the service so well that about 80 per cent. of it will eventually be salvaged. The sheeting was driven with care, and when a pile encountered serious obstruction by a boulder, driving on it was suspended and adjacent piles were driven down beyond the boulder and excavation made to undermine and move the boulder, or in some cases it was blasted and removed so that the piles could be driven without further trouble. By this scheme the sheeting was put down with very little battering.

Although water was encountered, no difficulty was experienced in keeping the foundations dry by the use of 6 and 8-in. centrifugal pumps. Most of the excavation was done by a 1½-yd. Williams bucket suspended from a derrick boom. The sheet piles were covered with tar paper to prevent adhesion of concrete, and the cofferdams were filled nearly to the surface of the ground with concrete deposited against the steel sheeting without the use of forms. After the concrete had set the sheet piles were pulled in sets of one, two or three by an eight-part tackle suspended from an A-frame and by a whip line led direct from the derrick boom to the hoisting engine.

Pier Construction.—Above the surface of the ground the pier concrete was placed in wooden forms made of large panels 17 ft. 9 ins. high, lined with galvanised iron. After four 4-ft. courses of concrete had been deposited in the form and the last course had set several days, the panels were disconnected, were hoisted 16 ft. by the derrick and reassembled in position for concreting above, and so on. Concrete was distributed to the piers in three-car trains, each taking two full buckets, with room to receive a third empty bucket.



Wooden Centering for End Span.
REINFORCED CONCRETE VIADUCT, MARTIN'S CREEK, U.S.A.

Pier concrete was laid during the coldest winter weather, care being taken to heat the water and the piles of sand and stone and to keep the forms warmed by steampipes under protecting tarpaulins. The maximum amount of concrete deposited in one month was 8,500 yds., working one ten-hour shift daily. About 6,000 yds. of this concrete were deposited in forms; the average haul was 800 ft.

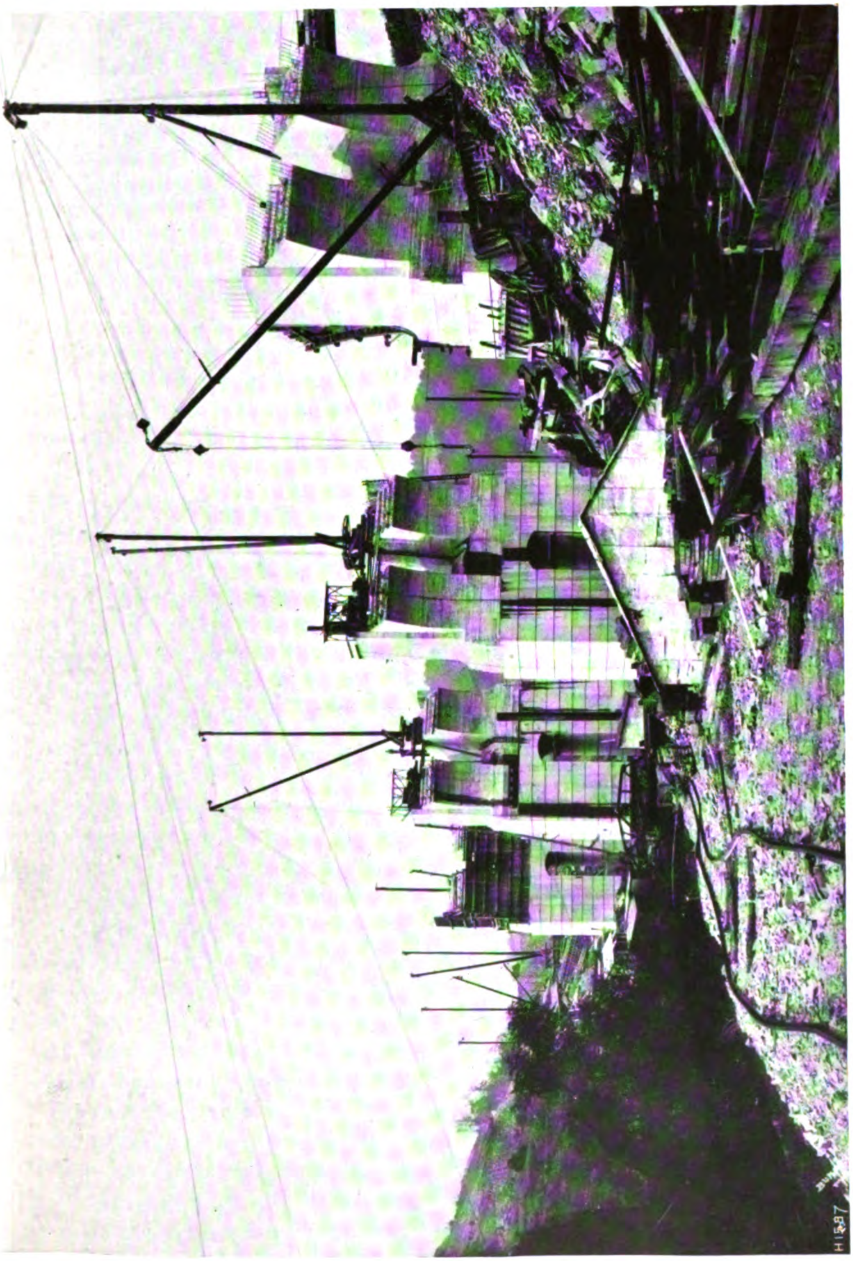
The concrete for each pier was handled by a guyed-derrick with a boom from 80 to 90 ft. long operated by a Mead-Morrison three-drum hoisting engine, of which sixteen are installed on the work, one for each derrick on the viaduct and three at the concrete plant. The derricks were at first set up on the surface of the ground or on timber towers at the pier site, and after the completion of the piers up to the top of the extensions for the arch ribs the derricks placed a ginpole on top of the pier and the latter lifted first the derrick masts and then the derrick boom to new position on top of the pier. The derrick then removed the ginpole and was in readiness to erect the steel truss centres for the concrete arches and to lay concrete upon them.

Arch Construction.—The 150-ft.-span arch ribs are built on steel truss centres. The smaller spans have wooden centres. Four steel centres, each having five ribs or trusses, have been provided and erected on the piers in readiness for the construction of one rib of each of four consecutive spans. After these ribs are completed and the concrete sufficiently set the centres will be struck and the sets of trusses will be moved as units 29½ ft. transverse to the axis of the bridge into the centre line of the other ribs which will be built on them, after which the centres will again be struck, the trusses they temporarily supported from the finished ribs separated into four pieces each, lowered to the ground by tackles suspended in the clearance between ribs, transferred to adjacent spans, re-erected, and so on until the spans are all completed.

After the concrete has set thirty days the centres are struck by means of the adjustable members in the crown panels of the trusses. Part of the concrete for the arch rings will be handled by the pier derricks. As these cannot reach to complete the spandrel walls and floor arches in the centres of the spans, it is probable that they will be supplemented by a cableway. Both ribs of each 100-ft. span are simultaneously concreted on centreing formed of timber trusses, with horizontal bottom chords supported on the umbrella projections from the piers and on a pair of eight-post framed centre towers.

Steel Arch Truss Centres.—The trusses, which weigh about 28 tons each, are erected four pieces each by the derricks on the piers. The end pieces are pin-connected to the steel grillages on the pier copings 11 ft. below the springing line, and are held in position by anchorage bolts passing through the tops of the concrete umbrella sections and by anchor bolts at the foot of trusses. They are self-sustaining until the crown sections are in turn hoisted by the derricks and bolted to them and the centre pins driven, making them self-supporting. In each set there are five trusses spaced 3 ft. 9 in. apart and braced together with sway frames and top-and-bottom lateral X-bracing with bolted connections.

The trusses are covered with lagging, of which the upper surface is dressed smooth and greased. Bulkheads are built on the sides and parallel to the axis of the arch to divide the ring into sections corresponding to voussoirs. These are concreted in pairs symmetrically placed on opposite sides of the centre, the work being done in the sequence indicated by the numerals on the accompanying diagram, so as to maintain balanced loadings on the centreing. After adjacent voussoirs are cast, the bulkheads between them are removed and the narrow portions of arch ring between them are concreted, forming keys which lock them together.



Completing Piers for Arch Centres.
Reinforced Concrete Viaduct, Martin's Creek, U.S.A.

The design and construction of the viaduct are under the direction of the engineering department of the Delaware, Lackawanna and Western Railroad Company, of which Mr. G. J. Ray is chief engineer, Mr. F. L. Wheaton engineer of construction for the Martin's Creek cut-off line, Mr. A. B. Cohen concrete engineer, and Mr. Walter Lozier resident engineer in charge of the viaduct. The contract for the viaduct was awarded to the F. M. Talbot Company, of New York City.

ELECTROLYSIS IN CONCRETE.

Report by E. B. ROSA, BURTON McCOLLUM and O. S. PETERS,
of the U.S. Bureau of Standards.

The question of Electrolysis in Concrete continually gives rise to discussion, and therefore the following short résumé of some experiments recently carried out by the U.S. Bureau of Standards may not be without interest.—ED.

PREVIOUS work on the danger to reinforced concrete structures due to electrolysis by stray electric currents has given somewhat contradictory results as regards the extent and nature of the possible damage. The question has now been re-investigated by the Bureau of Standards, and the principal results may be summarised here.

The experiments were made with cylinders of 1 : 2½ : 4 concrete, 6 inches in diameter and 8 inches long. The specimens were kept in wet sand for 20 days before use. One electrode was an iron rod, embedded along the axis of the cylinder; the other was a sheet-iron cylinder, placed in a vessel of water surrounding the test specimen. The central rod could be made anode or cathode at will, and the external electro-motive force could be varied within wide limits.

With a high initial potential difference, such as 57 volts, the central rod being the anode, there was at first a rapid rise of temperature, followed by a fall, due to an increase of the electrical resistance. The concrete was soon cracked, and then broke into several pieces. The damage was due entirely to rusting of the reinforcing rod, causing expansion. There was no disintegration of the concrete itself, as each broken piece was found to have its original strength.

With potential differences of 15 volts or less, cracking did not occur, and with concrete made from normal Portland cements there was practically no injury, although the total number of ampère hours passed through the specimens was actually larger than in the high voltage experiments. It therefore appears that damage due to oxidation at the anode is not likely to occur unless the leakage of current is abnormally high, and this danger is not a serious one. The coating of the reinforcement with copper or aluminium has been proposed, but is of no value, as both of these metals disintegrate readily in contact with concrete when a current is passed. The bursting pressure exerted by the iron in rusting was measured, and was found to be as high as 4,700 lb. per square inch. Even with high potential differences, corrosion was not found to take place when the temperature was kept low by artificial cooling. The addition of salt to the concrete increased the corrosion very greatly, owing to the increase of conductivity and to the destruction of the passivity of the iron.

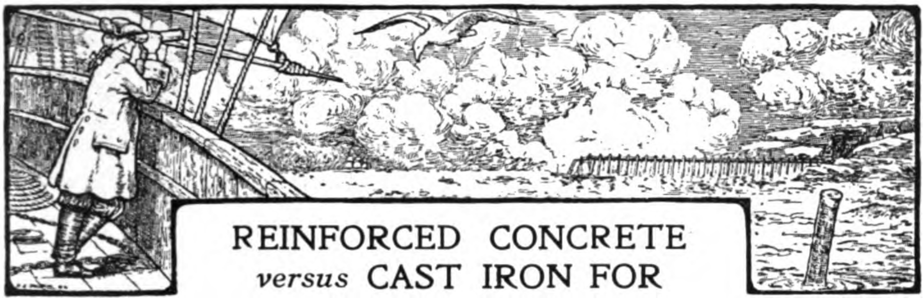
Contrary to previous observations, the concrete was observed to soften considerably in the neighbourhood of the reinforcing rod when the latter was made the cathode. The softening action began at the metal surface and spread outwards. The softened material regained its hardness on exposure to air, but remained brittle and friable. This action proved to be of greater practical importance than the corrosion at the anode, as it was found to occur with low as well as with high voltages, the action being roughly proportional to the difference of potential. The effect has been traced to the presence of alkali salts in the concrete. These salts undergo electrolysis, resulting in the formation of alkali hydroxide near to the cathode metal. At a short distance from the cathode no injury to the concrete could be observed. Any increase of alkali salts accelerated this type of injury.

One practical consequence of this series of experiments is that the suggestion which has been made to protect reinforced concrete buildings by applying an external electro-motive force, making the reinforcement the cathode, is worse than useless, as this would result in an acceleration of the disintegrating action.

Waterproofing agents were not found to have any marked effect in checking electrolysis. It appeared likely, but was not proved, that external waterproof coatings would be more effective than waterproofing agents used in the mixing of the concrete. Painting the reinforcement was of no advantage, and had the defect of lessening the bond between metal and concrete.

As precautions in actual practice, the authors make the following recommendations:—All direct current circuits within a reinforced concrete building should be kept free from earths, and tests should be made from time to time with earth detectors. Lead-covered cables should also be insulated. The general earthing of metallic conduits is not to be recommended, and although it is advisable to connect all the metal work of a building together as far as practicable, the connected metal should not be earthed.

The report contains a large number of quantitative determinations of resistance, etc., under various conditions.



REINFORCED CONCRETE *versus* CAST IRON FOR LIGHTHOUSE CONSTRUCTION.

By C. WESEMANN, Civil Engineer.

From examples previously given in our Journal, it has been found that reinforced concrete can be used advantageously for lighthouse construction, and although there may be individual instances where a different method is preferable for one reason or another, it would appear that great economy can be effected by the use of reinforced concrete.—ED.

An adequate comparison between two different forms of construction for lighthouses is almost impossible, owing to the varying conditions and local circumstances which attend this particular class of building.

Some interesting facts may, however, be ascertained by comparing the construction of a Dutch lighthouse erected some time ago in reinforced concrete and some newly built German lighthouses in cast iron. As regards site, size, transport of materials and available labour, the conditions in both cases were somewhat similar.

The question naturally arises as to how reinforced concrete compares with other systems of construction adopted hitherto for lighthouses, when it is a question only of light structures, as against so-called " heavy-weight " structures, exposed to the force of the sea waves.

It is proposed, in the first instance, to give some data regarding the general dimensions and constructional particulars of the Dutch lighthouse—a reinforced concrete structure—which was erected on the island of Goerree-Flakkee, near the village of Ouddorp, in Holland. (See *Fig.* 1.)

The building is situated on the top of one of those dunes so typical of the Dutch coast line. Owing to the peculiar nature of the dune sand, a relatively shallow foundation is permissible, providing always that the necessary precautions are taken to prevent the sand from being scooped out from below the foundation slab.

The height of the building, measuring from the top of dune to the platform, is 141 ft. The form of construction adopted is that of a cavity wall. The width of the outer shell at the base of the superstructure is 25 ft.; the corresponding width at the top is 12 ft. 6 in. The outline of the inverted cone is battered approximately 1 in 20.

The cross section of the concentric outer and inner walls is octagonal in shape. The two walls are interlaced and tied together at each floor level by means of girders arranged wheel shape on plan so as to form a monolithic structure.

The outer wall is strengthened at the corners of the octagon by means of eight buttresses; this wall extends to the full height of the tower, and this is

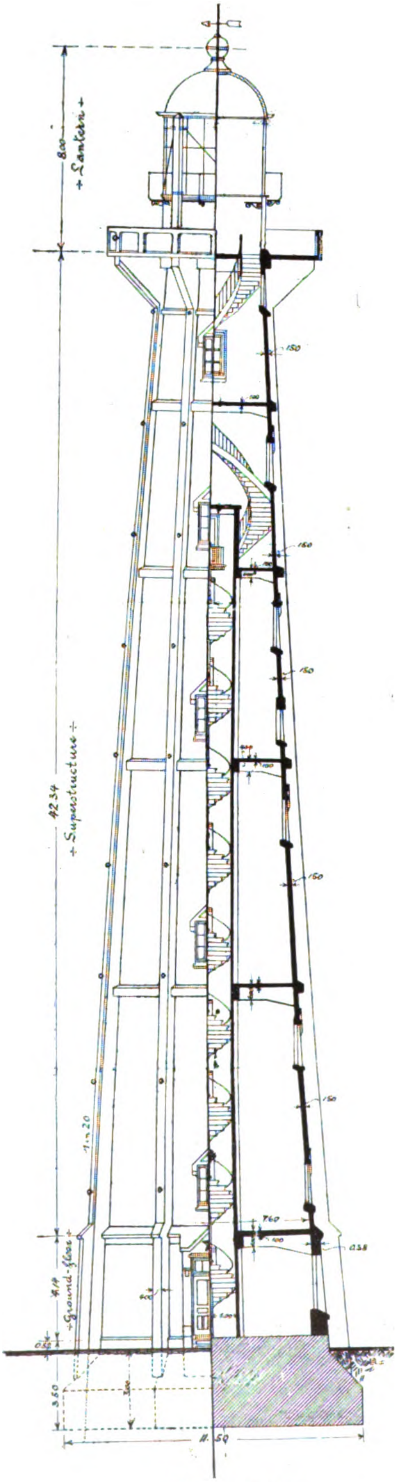


Fig. 1. Section.
Reinforced Concrete Lighthouse.

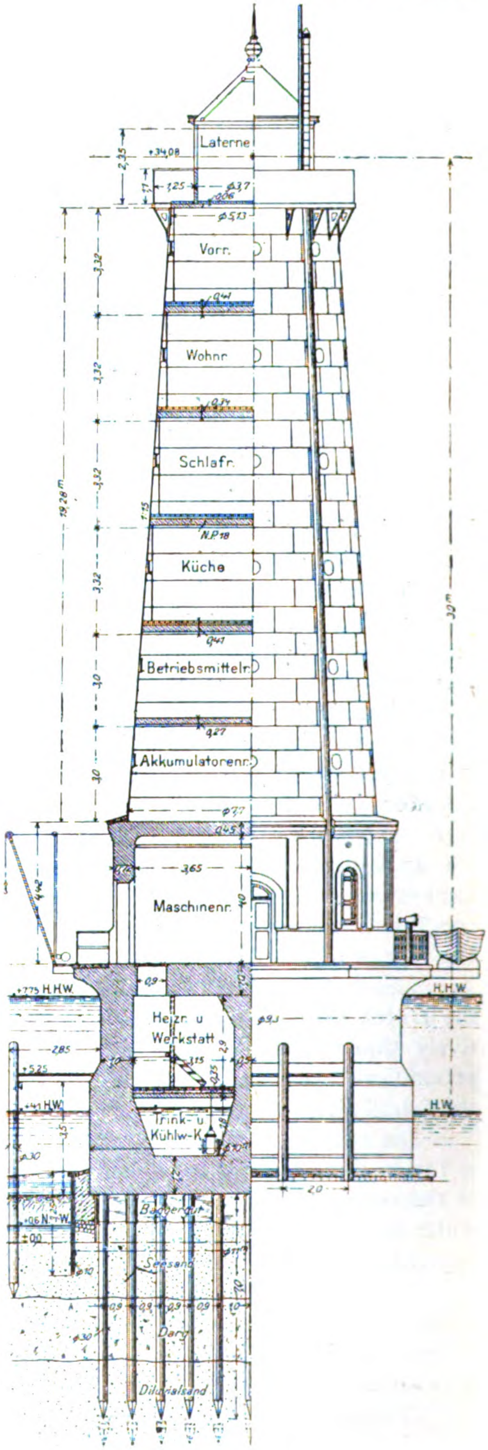


Fig. 2. Sectional Elevation.
Lighthouse of Cast Iron.

braced by horizontal girders extending round the octagon. The inner wall—whilst forming part of the construction—also serves as the staircase well. Although this arrangement interferes somewhat with the size of the rooms, etc., it is not particularly detrimental in this case, as the accommodation required for machinery equipment, storage, and dwelling purposes is very simple. The lighthouse in this instance merely serves as a beacon, and the lighthouse-keepers live in adjacent dwelling-houses.

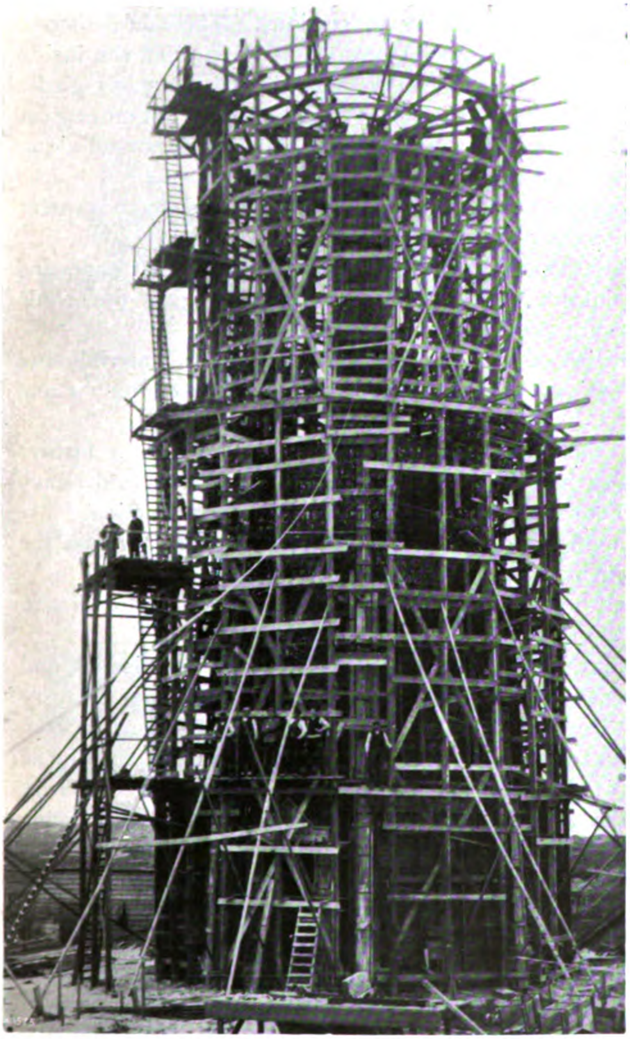


Fig. 3. View showing Reinforced Concrete Lighthouse in course of construction.
Lighthouse at Goerree-Flakkee.

The writer is of opinion that, in planning and designing future lighthouses in reinforced concrete, the inner wall might be dispensed with and the material thus saved could be employed in strengthening the outer wall. A mezzanine floor might be constructed between two floors so as to reduce the height of the stories.

The stairs could easily wind along the internal surface of the wall and be separated from the remainder of the building by a partition wall. A lighthouse constructed on these lines would be very similar to the one in cast iron illustrated in *Fig.* 5.

The cast-iron lighthouse illustrated in *Fig.* 5 is situated on a clayey "flat" outside the sea dyke, on ground which is rather soft and wet, and is covered with water by high spring tides. Before the actual building operations were proceeded with, a platform of solid clay was made in the form of a sea dyke. This platform carries the tower and two adjacent dwelling-houses for the lighthouse-keepers.

The building rests on high wooden piling, which was carried down to the bearing stratum. The height of the lighthouse is 112 ft. The width of the superstructure at the base is 25 ft. 4 in. and at the top 3 ft. 10 in. The outline is battered approximately 1 in 15.

The wall of the superstructure consists of cast-iron plates with horizontal and vertically planed flanges, bolted together in sections. The wheel-shaped girder grillage of steel rests loose on a special bearing flange around the inside circumference of the wall. The groove between the wall and the outer girdle of the iron grating is filled in with asphalt in order to allow of partial movement and to ensure a plastic joint. A special staircase well has been arranged along the inside wall of the inverted cone.

The internal surface of the cast-iron wall has been lined by a plaster insulating wall with an air space between.

The mean thickness of the cast iron is 23 mm.—viz., 26 mm. at base and 20 mm. at the top. A reinforced-concrete superstructure having the same average strength would measure about the same in centimetres.

The proportional quantities of the two respective building materials are 1 : 10, and the proportional weights (on the basis of the specific weights 7·2 and 2·1) are, approximately, 1 : 3.

The lighter weight of the superstructure naturally admits of a lighter foundation, but the proportion is smaller than 1 : 3, as the massive and heavy substructure of the ground floor is common to both forms of construction.

In comparing the two methods of building, the following are perhaps the most important points to bear in mind:

Where a site is a difficult one, a minimum amount of building material and lighter foundations may be a consideration.

Then, again, reinforced concrete requires a somewhat complicated and difficult scaffolding, which, when exposed to the rough sea weather, is very liable to damage. The cast-iron structure is easily put together by means of a simple hoisting plant without running much risk from weather conditions; and, also, the main portion of the work is carried out in the workshop. There are also instances where the lighter cast-iron structure might be preferable from the statical point of view, as, for instance, in earthquake districts.

In the example here under review, however, reinforced concrete has certainly proved to be the superior form of construction as regards cost and maintenance charges.

The cost of erecting the Dutch lighthouse in reinforced concrete, exclusive of equipment, was £3,550. This same building would have cost £5,500 if constructed in cast iron, in accordance with *Figs.* 2, 4 and 5. This shows a clear saving of one-third.

These figures only apply to this individual instance, but the question of cost is, of course, an important factor. In other cases the above saving might work out somewhat higher, or, in some cases, less, according to local conditions.

Figs. 2 and 4 show an instance where cast iron was used in preference to reinforced concrete. The lighthouse stands on a sandy " flat " in the middle of the Jade estuary near the naval station of Wilhelmshaven. The site is

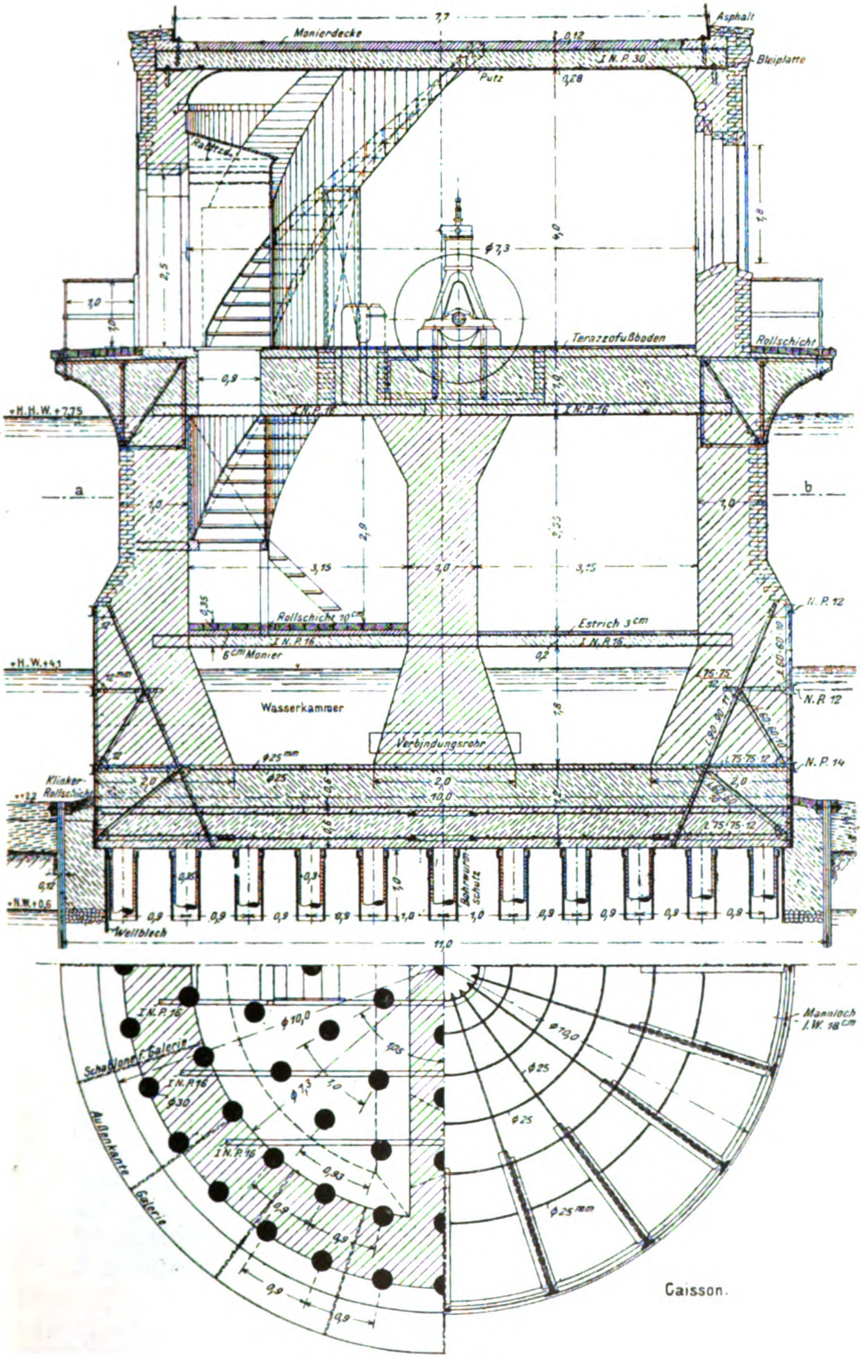


Fig. 4. Section.
LIGHTHOUSE AT WILHELMSHAVEN.

moderately exposed, and becomes dry during three hours at every ordinary tide, the rise and fall of which is 11 ft. 6 in. The tower height from sea level (ordinary high water) to the main focal plane is 30 m., or 98½ ft.

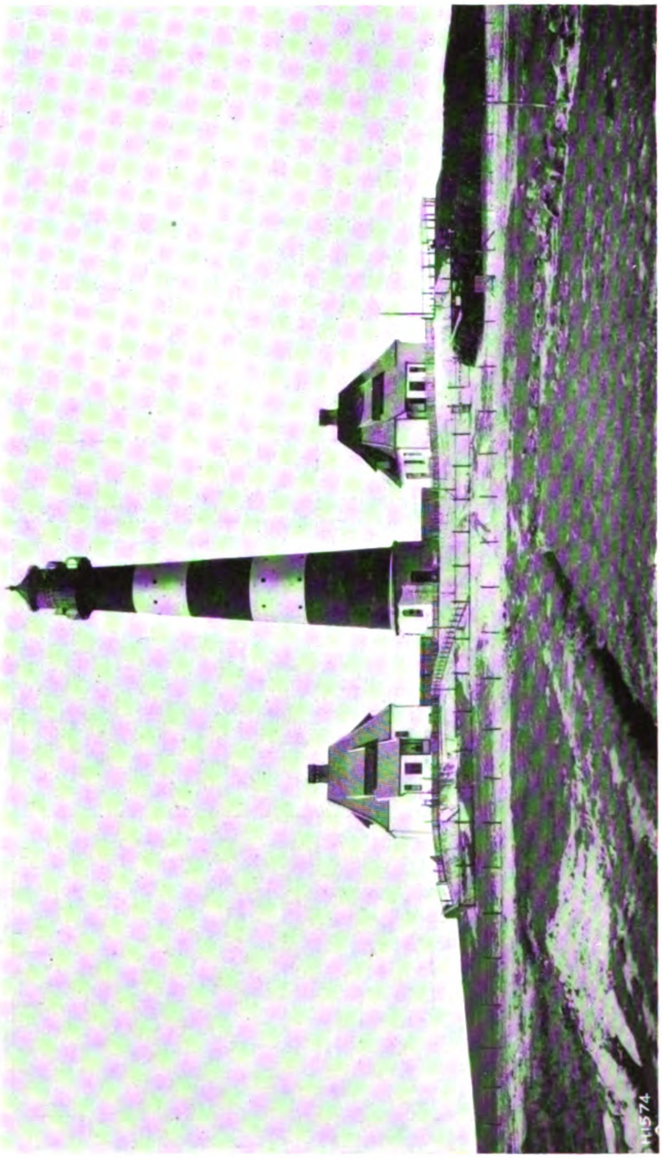


Fig. 5. View of Finished Lighthouse.
LIGHTHOUSE, WESTERHEVER SAND.

The foundation consists of a circular caisson, which has been provided with a permanent watertight bottom in reinforced concrete. The caisson was fitted up and constructed with its reinforced concrete bottom in a dry dock on a platform which had been specially prepared to ensure an absolutely level bottom face. The caisson was then floated into position and sunk down upon the piling. The tops of the wooden piles were spherically shaped, so as to admit of the caisson resting upon an absolutely level base. The substructure was then built up in masonry, in the dry, and faced with Dutch clinkers. Brush mattress work has been placed around the foundation as a protection against scouring.

The lighthouse is fitted with a double set of 12 h.p. Diesel engines, electric flash lights and central heating. The usual accommodation for dwelling purposes and storage of fuel, cooling water (fresh water), coal, provisions, etc., has been provided for.

The cost of this lighthouse, complete, including designs, and supervision of the building, amounted to £9,000; £3,000 of this was devoted to machinery and other equipment.

Fig. 6 shows the machinery equipment of the two lighthouses.

A few words should be added regarding the architectural aspects of the case.

In this article, lighthouses have been dealt with which were constructed in the shape of an inverted cone and with a straight outline, somewhat resembling a chimney of wide circumference.

If the contour line were arched inwards, with breaking points in the level of the floors, the building would present a better and more pleasing appearance.

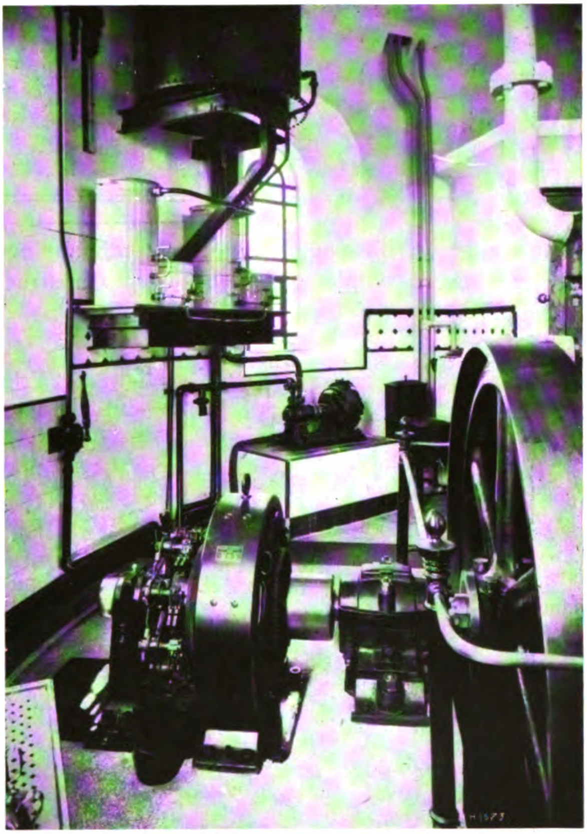
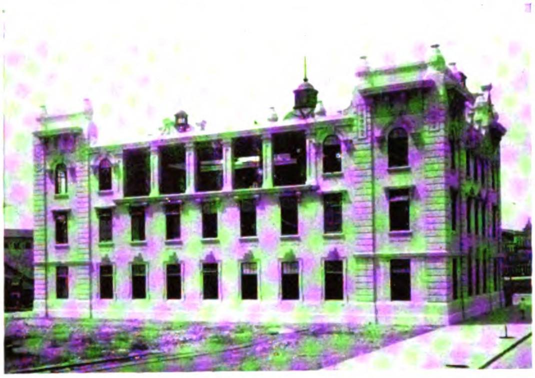


Fig. 6. Interior View.
MACHINERY EQUIPMENT.

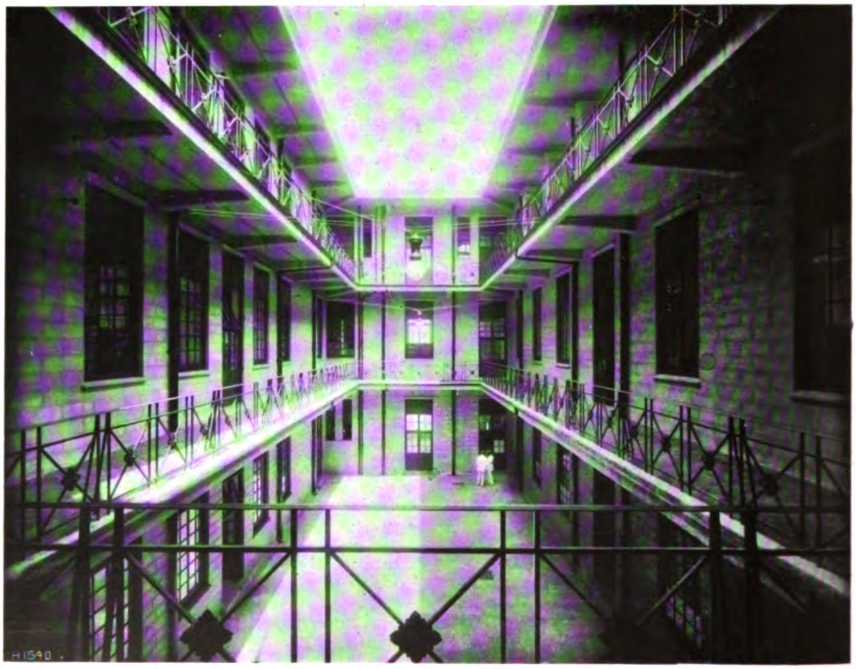
The author is indebted for the drawing of illustration (*Fig.* 1) to the Dutch engineers in charge of the supervision of the building, whilst the remaining photographs shown and the details as to prices, etc., are taken from the writer's own personal experience.



REINFORCED CONCRETE BUILDING AT PARA, BRAZIL.

Reinforced concrete is being used to a great extent on the new structures in course of erection in South America. This form of construction is admirably suited to the conditions prevailing in that country, and we give below an example of a large building erected there recently.—ED.

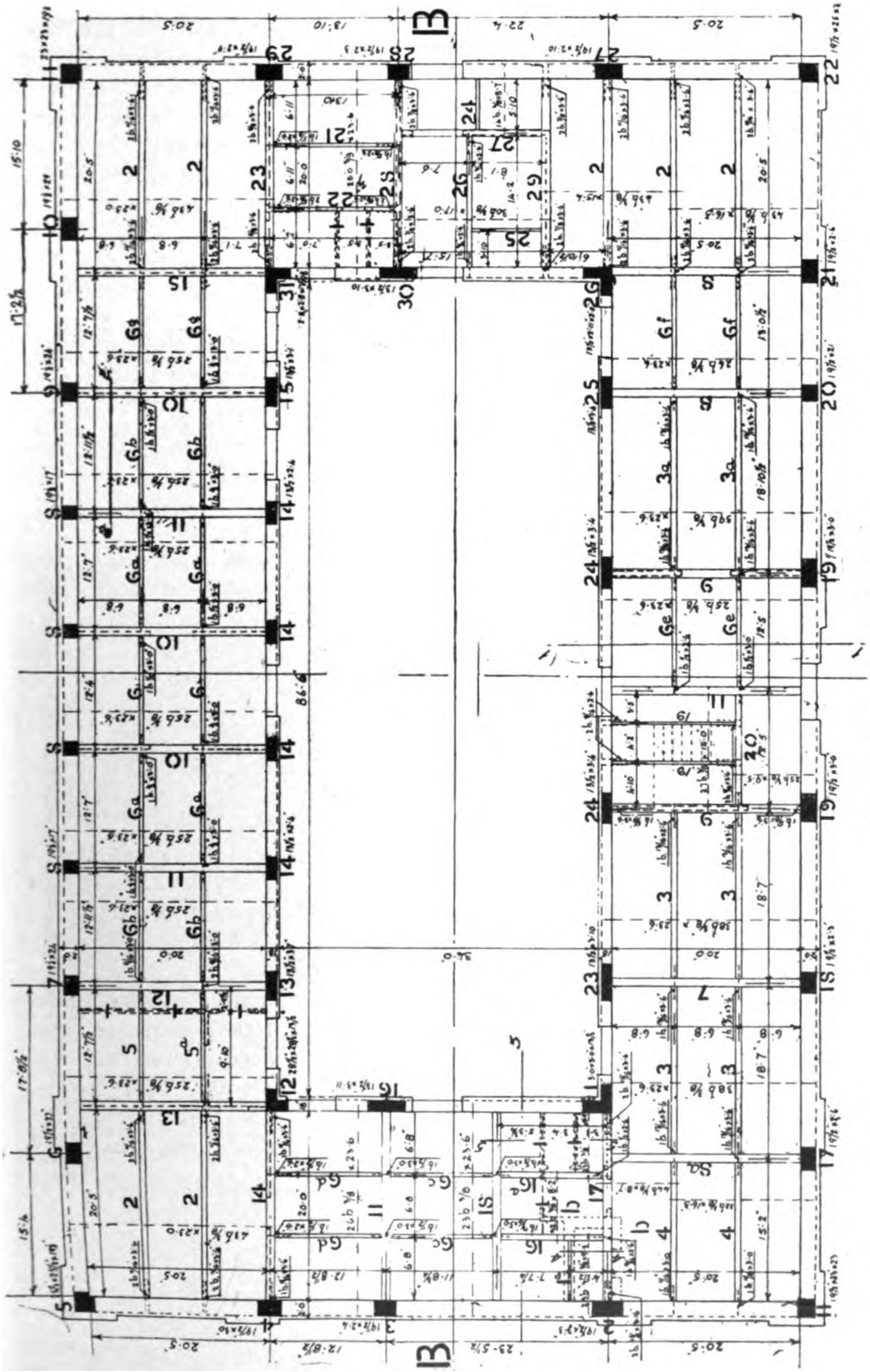
THE building illustrated by the accompanying photographs and plans has recently been completed by the Para Construction Company, Ltd., for the Administration Offices of the Port of Para.



View of Internal Court.
REINFORCED CONCRETE BUILDING AT PARA, BRAZIL.

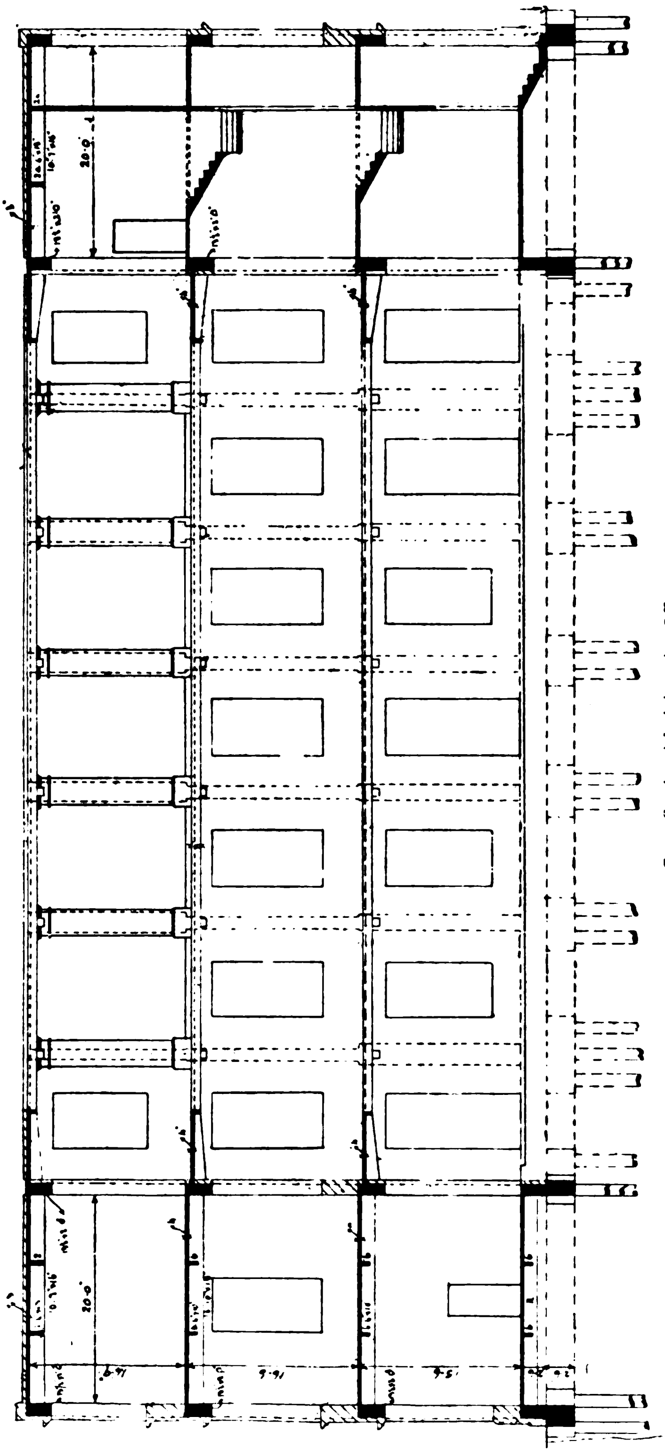
The entire work, excepting the walls, was constructed on the Coignet system of reinforced concrete.

The office accommodation is disposed around an internal court and the principal over-all dimensions of the building are 134 ft. long by 81 ft. wide.



Plan below Ground Floor (looking up).

REINFORCED CONCRETE BUILDING AT PARA, BRAZIL.



Cross Section Administration Office.

Reinforced Concrete Building at Para, Brazil.

The height is 52 ft. to the top of the flat roof, and from the foundation to the top of the domes is approximately 70 ft. The internal court measures 86 ft. long by 34 ft. wide.

The building was erected on reinforced concrete piles of about 14 in. diameter, and 30 ft. long, and arranged in groups of two, three and four connected together by means of reinforced concrete caps and beams. The piles were made on the site and were driven through sand and mud to hard ground by means of a steam pile-driver.

As shown in the accompanying plans, the building is composed of a ground floor, first and second floors and a flat roof, and cantilevered balconies 7 ft. wide are carried around the internal court to give access to all the rooms. The total area of floors, flat roof and balconies amounts to about 38,000 sq. ft.

The reinforcement for the pillars, beams, floors, and other parts of the reinforced concrete construction was composed of round steel bars. These bars, the cement, the granite chips, and a certain amount of timber were the only materials which had to be sent from England for the erection of the work.

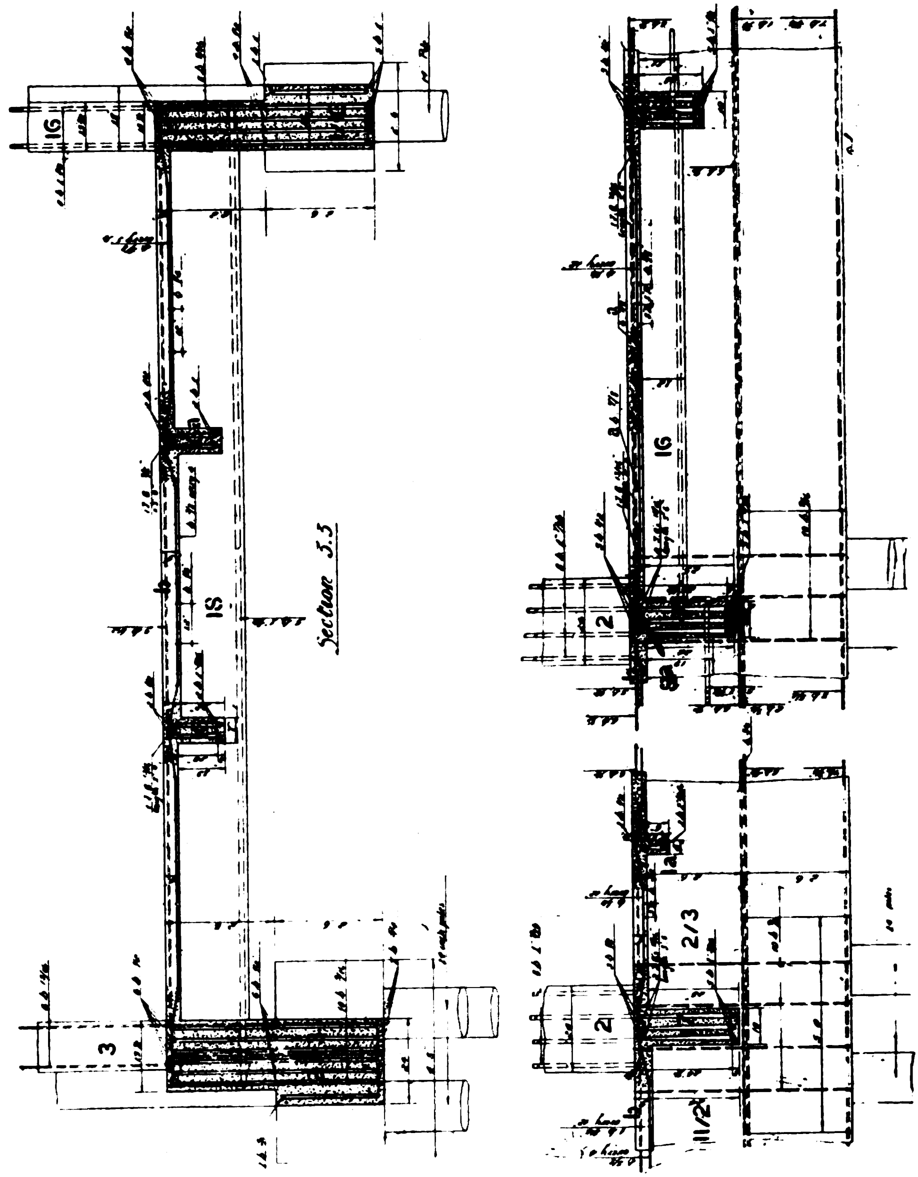
As shown in the accompanying plans, the pillars were composed of a certain number of longitudinal bars of small diameter bound together by means of a spiral wire. The beams were formed by a certain number of straight bars in the lower and upper portions of the beam connected together by means of wire stirrups, and the slabs were composed by means of a meshwork of small bars.

This is another example of the considerable advantages offered by the use of reinforced concrete for work in the Colonies, or in distant countries where the labour of bending the bars and putting them together must be done by natives.

View of Entrance Hall and Staircase.
REINFORCED CONCRETE BUILDING AT PARA, BRAZIL.

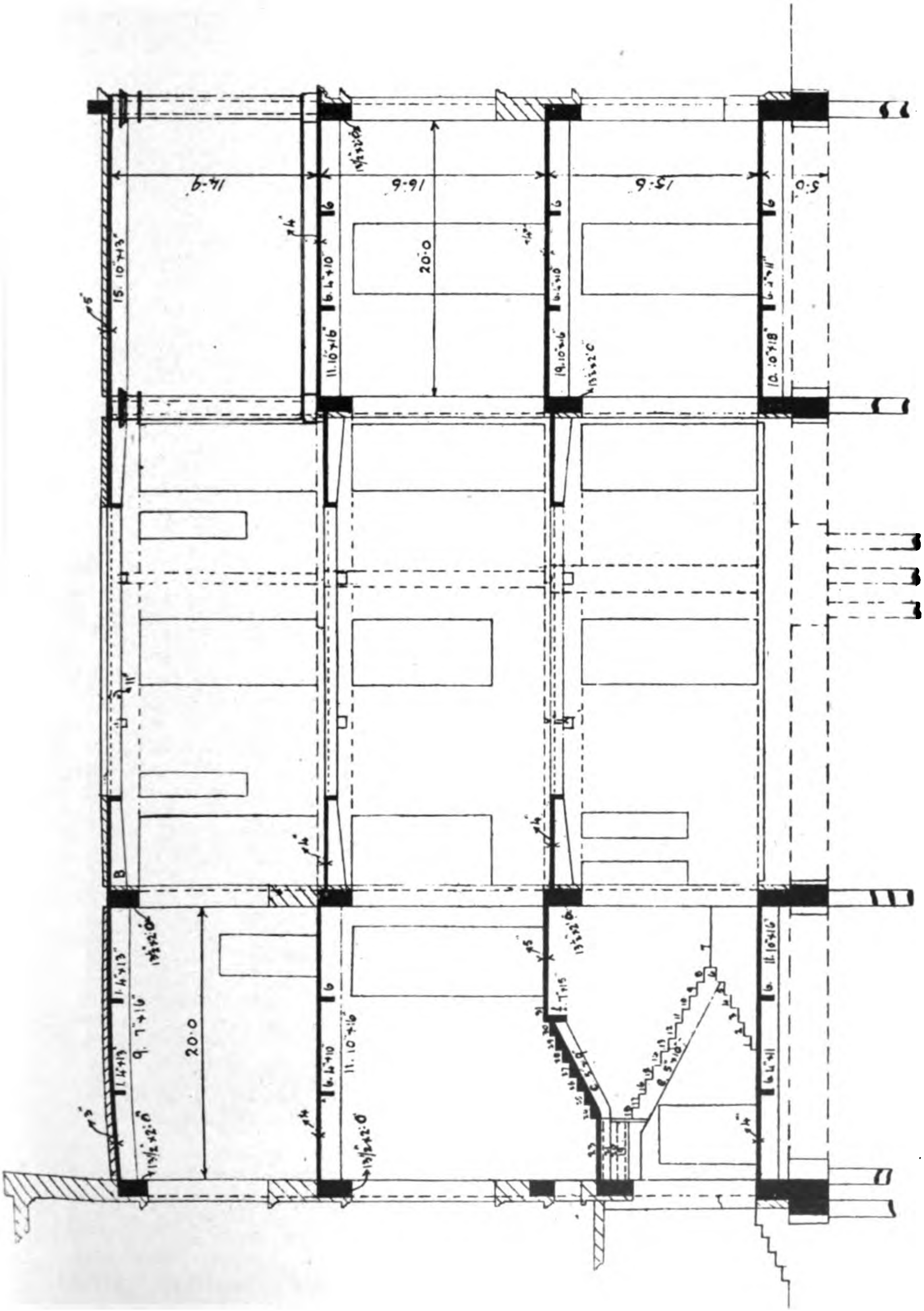
It is interesting to point out that the steel frames of the columns and beams in the method here employed are all made in advance on the ground level and hoisted into position in the moulds ready for the concreting operation. As all the bars are rigidly connected and tied together no displacement of any member is possible whilst the concrete is being rammed in position, and this of course simplifies considerably the supervision of the work.

The walls of the building are carried by the reinforced concrete framework, the framework of each floor supporting its corresponding load of walls, and the walls are formed of hollow concrete blocks moulded in advance of the work by a special machine. The three domes were constructed of timber and covered with copper.



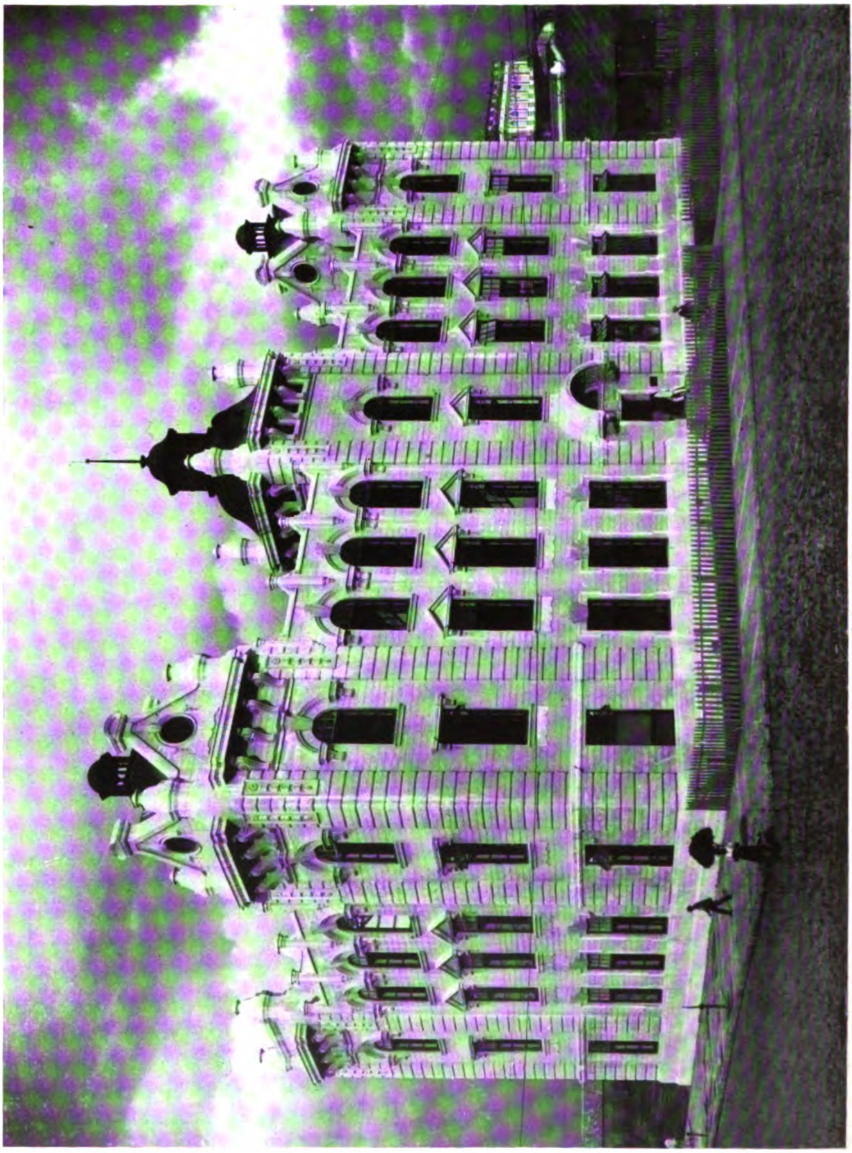
Sections—Details of Ground Floor.
Reinforced Concrete Building at Para, Brazil.

The building was erected by Messrs. W. Cowlin and Sons, contractors, of Bristol, entirely by native labour under the supervision of a few Europeans. The architectural plans were prepared by Mr. E. M. P. Fisher, architect, of

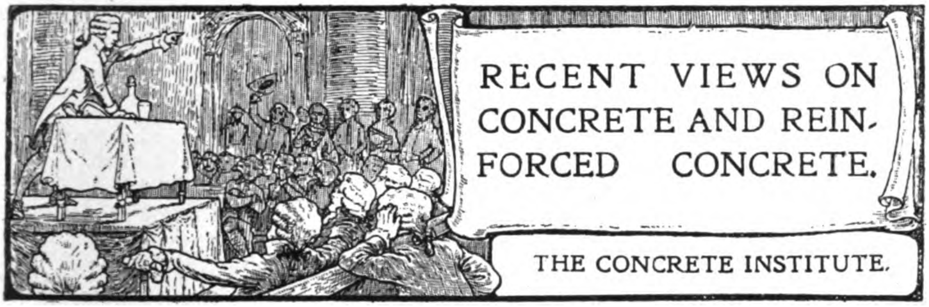


Cross Section Administration Office.
Reinforced Concrete Building at Para, Brazil.

London, and the whole of the work was carried out under the instructions and control of Mr. J. W. Kitchin, engineer of the Para Construction Co., while the detailed plans and working drawings for the reinforced concrete work were designed and prepared by Messrs. Edmond Coignet, Ltd., of 20, Victoria Street, Westminster.



View of Finished Structure.
REINFORCED CONCRETE BUILDING AT PARA, BRAZIL.


RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.
THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

FORMS FOR CONCRETE WORK.

By **ALLAN GRAHAM, A.R.I.B.A., M.C.I.**

The following is an Abstract of a Paper read before the Concrete Institute at their forty-eighth ordinary general meeting. The Paper was illustrated by numerous lantern slides, and was also accompanied by a large number of interesting plates. A short report of the discussion which followed is also given.

It has been recently stated, with some truth, that we do not often hear of failures occurring in reinforced concrete buildings after their completion, but generally during their erection, and although all failures cannot be attributed to defective forms, yet the forms are to blame in a sufficient number of cases. Although it is not the practice, in England at any rate, for engineers to design their forms, an engineer, for his own protection, should at least set out some typical portion of the forms for the contractor's guidance, thus doing all he can to circumvent failure in this direction at any rate. Of course, good forms alone will not ensure safety, and we have to use vigilance likewise in detecting bad work, bad design, and bad material.

The contention that the engineer should prepare the design of formwork has much to recommend it. It is not merely that a design is required for a specific case which will safely support a certain volume of concrete, it is rather the problem of designing a set of forms which can be erected, taken down, and many times re-used during the progress of the work.

TIMBER.

The first important consideration is the timber to be used. White pine, yellow pine and spruce are all excellent for the purpose and should be free from knots, and must not be so dry that they will absorb the water from the concrete and so swell and bulge as to entirely distort the forms. On the other hand, if the timber be green it will shrink and cause the same trouble. Varieties with hard surfaces should be chosen in order that forms may be oftener used before dilapidation.

The timber has to resist the weight or pressure when a considerable height of wet concrete is being poured, as in walls and columns. Many authorities calculate this pressure as a liquid of half its own weight—namely, 75 lb. per cu. ft. When the concrete is placed in layers no calculation is necessary, as it has been found in practice that for beams the bottom boards should be 2 in. to $2\frac{1}{2}$ in. thick, with sides $1\frac{1}{2}$ in. to 2 in. thick. Column sides should be $1\frac{1}{2}$ in. to 2 in. thick. For walls $1\frac{1}{2}$-in. boards are used. Of course the thickness of boards can be varied just as we place the clamps or braces, but it must not be overdone, nor the material made too thin. A more solid board will ensure greater economy, from the fact that the form can be used over and over again. For slab panels 1-in. stuff is generally used, but 1-in. boarding requires staying every 2 ft., 1½-in. boarding requires staying every 3 ft., 2-in. boarding requires staying every 4 ft. to 5 ft. Studs should be of sufficient size and spaced so as to prevent the boards between them springing.

They may be 2 in. by 4 in. to 2 in. by 6 in. if not used beyond 2 ft. to 3 ft. centres; 3 in. by 8 in. may be spaced about 4 ft. 6 in. centres; 4 in. by 10 in. at from 6 ft. to 8 ft. centres; 6 in. by 12 in. from 8 ft. to 10 ft. centres; but the spacing of the supports must be governed by the nature of the weight coming upon the boards.

CAMBER.

It is also necessary to give to beams a camber of at least ⅛ in. in 5 ft.—*i.e.*, $\frac{1}{480}$th of the span. This generally comes out during the ramming and tamping of the concrete and in the squeezing of the wedges. After the filling, the beams should be examined to see if the camber has come out during the process of tamping, so that it may again be secured by tightening up the wedges before the concrete has set.

In cases where a great deflection was found in the beams, the failure of the supports to the studs has been the root cause, probably owing to soft ground. For that reason a little judgment should be used to see that the sole plates under the supports are sufficiently large to distribute the load safely over a sufficient area.

MEASUREMENTS.

It should be carefully noted that the measurements are accurate and that the inside dimensions shown on the plan are secured, for the examination of several failures showed that the members were actually carried out to smaller dimensions than designed.

ALIGNMENT.

The forms should be carefully examined to see that they are truly vertical and horizontal and that the joints are closed so that no part of the mixture can escape.

CRACKS.

Any cracks found in the boards can be remedied by filling with plaster of Paris or clay.

DESIGN.

The forms should be so arranged that the slab forms and sides of beam, girder and column forms can be removed first, allowing the bottom boards of the beams and girders to be supported for a longer time.

EXPOSED CONCRETE.

Extra care should be taken with the forms for all exposed concrete, which should be made of bevelled-edged stuff. Some use tongued and grooved, but this allows no opportunity to expand, and the boards cannot be used again. Undressed timber may be used for backing, but it must be watertight.

CLAMPS AND NAILS.

Clamps should be used to hold the forms together, as the use of nails and spikes so destroys the timber as to render it unfit for re-use. The pressure of concrete will generally hold panel boards in place with scarcely any nailing. Where nails must be employed they should not be driven home but left so that they may be withdrawn by means of a claw-hammer.

REPAIR OF FORMS.

If forms have been left for a time exposed to the weather they should be gone over again and properly aligned, and any open joints repaired.

ECONOMY.

Formwork should be constructed with a view to economy in taking down, rather than in cheapness of erection.

RE-USE.

Before re-use the forms should be cleaned again, and the sides and ends should be freshly jointed, so as to have a perfectly smooth finish to the concrete.

SUPPLY OF FORMS.

The number of sets of forms required to begin with varies with the kind of building, the weather conditions, and the speed of construction required.

On an average 1½ sets of forms is a "fair" allowance. With this number erection on the floor above can begin while the concrete below is green. Yet there are many firms who use only one set of forms in a building, no matter whether it be 2 stories or 10 stories high, with of course the additional timber for girder bottoms and supports left in. A building of large floor area can be done in sections, setting up, say, one-half of the floor area at a time, so that the forms for only about three-fourths of one floor are needed with the extra beam bottoms and posts. It will be self-evident that in a high building, small in area, two sets of forms will be needed to get on fast enough.

CLEANING OF FORMS.

All forms should be cleared of all sawdust, dirt, and chips before pouring. Pockets or traps should be left at the bottom of the forms for this purpose. If one side of a pillar form is brought up board by board as the concrete is filled in, of course no door or trap will be necessary.

WETTING ALL FORMS.

All forms, if not coated with some oil, should be thoroughly wetted before the concrete is poured. Some persons whitewash the forms, but it is not really necessary if the boards are wrought and properly wetted to close the pores before the concrete is applied.

SHEET METAL.

Some authorities, in order to give a presentable surface to the concrete, line the inside of the forms with 20 gauge sheet metal, but however carefully this is done the nail-heads show. It is also liable to become indented and show an imperfect face on the concrete.

STRIKING.

If possible, all forms should be left one week, the beam sides being first struck, the bottom and strutting being left three weeks. If there is frost or continued wet weather, the period of duration of the frost or rain should be added to that time.

For members of exceptional sizes, the engineer's judgment must be exercised, but 28 days should be allowed before striking.

FLOOR AND PILLAR FORMS.

By far the greatest portion of the formwork encountered in building is mortgaged to pillars, girders, and slabs, and it is a close and ingenious consideration of the application of forms to these items that seems to point the way in the direction of economy.

There is a great similarity between the various types of forms for slabs and beams, but there are many varieties of the three types of column forms. Forms for square pillars as a rule are made with three sides complete and one side left open for tamping and for supervision. The fourth side is brought up as the concrete is deposited. Another method is to build up the whole four sides gradually with horizontal boarding, and the third method is, of course, to have the whole four sides entirely completed. This method demands a wet mixture, which must be poured in from the top. Each of these methods have their advocates.

STEEL FORMS.

The use of corrugated steel to support floor slabs, both as temporary centering and to be left in place permanently, represented one of the earliest attempts to employ steel forms for concrete construction and has continued in use, having been used as lagging to support concrete floors of flat slab construction in cases where the corrugations on the ceiling are not considered objectionable. The ease with which it can be placed and moved on without appreciable damage and its cheapness has caused its adoption in a great deal of factory work, especially where the cost of ordinary formwork was considered prohibitive.

Tall Chimneys.

In America Ransome's system of building chimneys largely obtains; it has made no progress in England. Its large square scaffold tower, with the outer and inner moulds suspended from it, does not appeal in this country because of its complicated construction.

[Here the author threw on the screen an illustration of a chimney at Northfleet.] The forms or moulds for constructing the chimney consist of two rings of six sections held together by latches to form a mould. Two outer and two inner sets are used in erecting the chimney. These forms, which are 3 ft. high, enable the chimney to be erected at the rate of 6 ft. per day. As soon as the forms are filled to the top the bottom form is released and placed on the upper form, the bottom mould being safely held in position by the frictional resistance of the concrete.

The concrete is tamped round the rods, which are held to their true alignment by the aid of the spliced wooden guide ring of two ¾-in. layers placed 6 ft. above the top of the form, being shifted up as the chimney rises.

Of course the working platform is carried up inside the chimney of scaffolding built up section by section. The framing of each section consists of four uprights properly braced, on top of which stout planks are nailed so as to form a square. An aperture is left in the platform for the hoisting of materials.

Silos.

In order to save timber, forms should be so arranged that they can be struck easily and moved up as the concrete sets. [Here illustrations were shown of some silos carried out by Messrs. Bradford.] The form is not only very light, but it has all the requirements of a good form—namely, ease of handling, economy of material and labour, and easy re-use. The forms are made in 12-in. heights of boards, with four angle posts fixed to the boarding, so that the bottom ends project 1 in. below the boards and the top ends 1 in. below, thus enabling one form to fit on to the other. Each side is obliquely cut at a greater angle than 45 degs., making the form into four segments, with stays at the four angles. There is a counter-sunk plate at the back of the form. The ½-in. hold on the concrete is sufficient to keep the forms in position, and they enable the forms to carry planks on top as a working platform. Three forms in height are always in position; they are filled with concrete at the rate of one form a day, so that by striking the bottom form and placing it on the top every form remains in position 3 days, giving the concrete good time to set. To strike the form the thumb-screws should be undone and the corner pieces pulled out. The holes left by the ends of the thumb-screws are brushed and finished with cement mortar.

In America the latest bin and elevator forms are on the moving principle. The forms consist of horizontal framing pieces to which vertical sheeting is attached. The form varies in height from 3 ft. to 5 ft.; it must extend along both sides of each wall, the forms on the two sides of the wall being connected by vertical timber or steel yokes which are usually attached to the horizontal framing of the form. The boarding is generally covered with sheet steel, but wooden sheeting is quite satisfactory if the raising of the form is carried on rapidly. In order to obtain smooth walls, then, it is necessary that the forms be raised continuously, and this is generally done with screw-jacks, and many of the large contracting American firms have solved the problem in their own way.

Bridges.

The progress of concrete applied to bridge design reads like a romance. While twenty years ago there was hardly a concrete arch in the United States, to-day they can be numbered by their tens of thousands. It is the same in Europe. By persistent effort the advocates of concrete have been able to gradually convince the authorities that the extra cost of concrete bridges over steel is money well expended, for the concrete bridge has met the requirements of the ideal highway, because of its possession of the following qualifications:—

1. Permanence, and its increase of strength with age;
2. Simplicity in design and erection; and
3. What is very important, the repairs and upkeep are reduced to a minimum.

Therefore special attention has been paid to the forms and centering for this class of work, as it is the author's firm belief that concrete will come more and more into use for bridges in this country.

[The author gave numerous illustrations of forms for various kinds of structures such as culverts, conduits, silos, tanks, dams, etc. Under the heading of Domes some interesting slides were shown of domes erected in recent years in England, Australia, and America. The section " Bridge " was also excellently illustrated, but we are unable to make reference to the numerous examples quoted.]

DISCUSSION.

Mr. M. Noel Ridley, M.Inst.C.E., said he considered the question of the many forms was to all engineers engaged in reinforced concrete construction certainly one of the most important things they had to deal with. He agreed that the engineer should design the forms as far as possible, but unfortunately there were great difficulties in the way owing to the amount of timber wasted and the number of bolts lost. One of the greatest troubles they had was the question of centering, and until they could get a system that would obviate the amount of timber and strutting up that they had, he did not think they would overcome the difficulties. Timber frames were a most expensive item in the cost of reinforced concrete and a most unsatisfactory item, and the sooner they devised a satisfactory method of improving it the better. He personally had, to a certain extent, gone on the lines of reducing the amount of centering. He had been able to dispense with all centering otherwise than two steel-wire ropes, and for long span bridges that type of construction, modified in certain respects, would be of very great use. In ordinary work he used a great deal of dove-tailed, corrugated steel sheeting. In using that, the sheeting was left in and was not removed afterwards. It was necessary to plaster the under-side so as to get an architectural effect, and they were able to put in a type of ornamentation on their columns and beams very simply and very easily. In small domes he did not use any centering at all. His method of construction was light weight bars only $1\frac{1}{8}$ in. by $1\frac{1}{8}$ in., which he bent as ribs to the dome; he put sheeting in between those, then the concrete on the top, and rendered on the other side.

Mr. T. A. Watson, Assoc.M.Inst.C.E., thought Mr. Graham might have devoted more time to the ordinary centering and a little less to the bridge work. In England they very seldom saw or heard of a bridge of over 100 ft. span being constructed. The majority of spans in England did not exceed 50 ft. For that reason, and because the cost of centering for ordinary floor was an extremely expensive item, he wished that the author had dealt more in detail with the forms of construction likely to be met with here. One difficulty they were always met with and always trying to find some way out of as regarded centering, was taking it down. It was fairly easy to construct it and put it up in place, but it was exceedingly difficult to take it down. He fully expected the author would have had some suggestions for the easy striking of centering. Referring to struts generally, poles were a great deal used amongst contractors, but unfortunately at present there was a dearth of scaffold poles, and tie struts were rather expensive, so they had to invent a new method of strutting the beam bottoms, and in order to make the most of the timber at their disposal they had been using recently 6 in. by 2, or 7 by 2, or even 5 by 2, spaced about 12 to 18 in. apart, and these things formed a sort of steel structure of a signal post, by which means they got for the largest diameter the excellent width of the centering. They got less deflection and they were able to put a greater load per square inch on these props than they would in the ordinary way. It seemed to him that was a fairly economical way of propping centering. He did not think the author had made as much as he might have done of the reinforced concrete centering for bridges.

Mr. Percival M. Fraser, A.R.I.B.A., remarked that what had been said about an engineer designing his own centering might apply to engineering works, but he hardly thought it applied to architectural works. It was a matter of contractors' plant, which an architect was well advised in avoiding taking any responsibility for. An architect should pay much more attention to his specification and specify a minimum thickness for his centering. He failed to understand why the word " centering " should be cavilled at. Various authorities placed tne cost of form work at anything from 20 to 60 per cent. of the cost. That disparity showed that nobody could possibly lay down or estimate the cost which the centering had to the whole job; it absolutely depended on the nature of the work, and it was easily much more than 60 per cent. or less than 20 per cent. He regretted that Mr. Graham had not given them a really good type of centering for a circular silo, which was much more economical in cost than the square silo.

Mr. S. Bylander, M.C.I., supported the use of the word " form," and remarked that if the Concrete Institute adopted it, everybody would use it.

Mr. William A. Haskins, M.C.I., as a quantity surveyor, said it was necessary for him to convey to many minds, by words alone, what they had to put their value upon, and, although he welcomed the word "form-work" as indicating the necessary preliminary structure for reinforced concrete work, he thought it would be altogether inadvisable to depart—in fact, almost impracticable for a very long period—from the customary terms.

Mr. Cyril W. Cocking, M.C.I., asked Mr. Graham what his factor of safety was for the stresses he gave for timber pillars.

The President said he found the relation the cost of centering bore to the cost of the work varied between 10 per cent. and 100 per cent. It could, therefore, be easily understood that where contractors were, as a rule, given the cube of the concrete and had put on the cost of centering, how lamentably they must be at sea.

Mr. ALLAN GRAHAM'S REPLY.

In replying, the author stated Mr. Watson had adversely criticised the American form of centering, but that form had been criticised for ten or twelve years, and it was the result of ten or twelve years' criticism—the accumulation of facts and the accumulation of practice. He was afraid it was a misnomer to call it the English practice, because there was no practice; every job they went on they found a different style adopted. It was that very different style that enabled joiners to use their material up for all they were worth. Replying to Mr. Fraser, though an engineer had no blame whatever for the centering, if an accident happened in a building for which he was the engineer, the odium would attach to him just the same. That was the reason he protected himself by saying if they did not do the centering themselves they should make the contractor submit his idea for approval. With regard to the cost of centering he had known a difference of as much as 30 per cent. between two different contractors tendering for the same job, so there must be some standardisation or else they would never get any further. Circular silos were more generally erected in America, but nearly all the silos in England, with few exceptions, were square. That was the reason why he gave the two types of ordinary centering. Referring to Mr. Haskins' observations, he explained that he was not concerned with the finishing of the building at all, but only with concrete structures as concrete structures from the surface. In answer to Mr. Cocking, the greater portion of the formula he used was based on the Rankine formula, but when they got to a certain height he shifted over to the Euler formula, as being square.

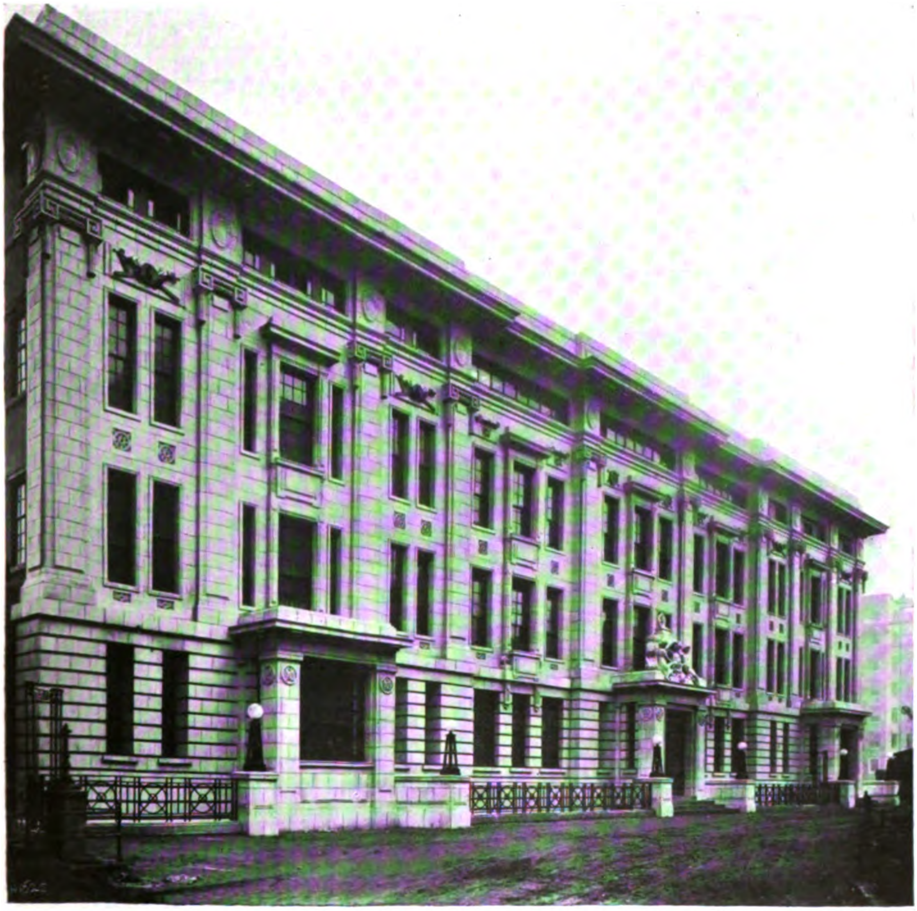
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE IN THE NEW OFFICES OF THE METROPOLITAN RAILWAY.

A HANDSOME building has quite recently been executed, almost entirely in reinforced concrete, for the accommodation of the staff of the Metropolitan Railway, so that the previous offices which were scattered in various parts of the company's system are now concentrated under one roof.

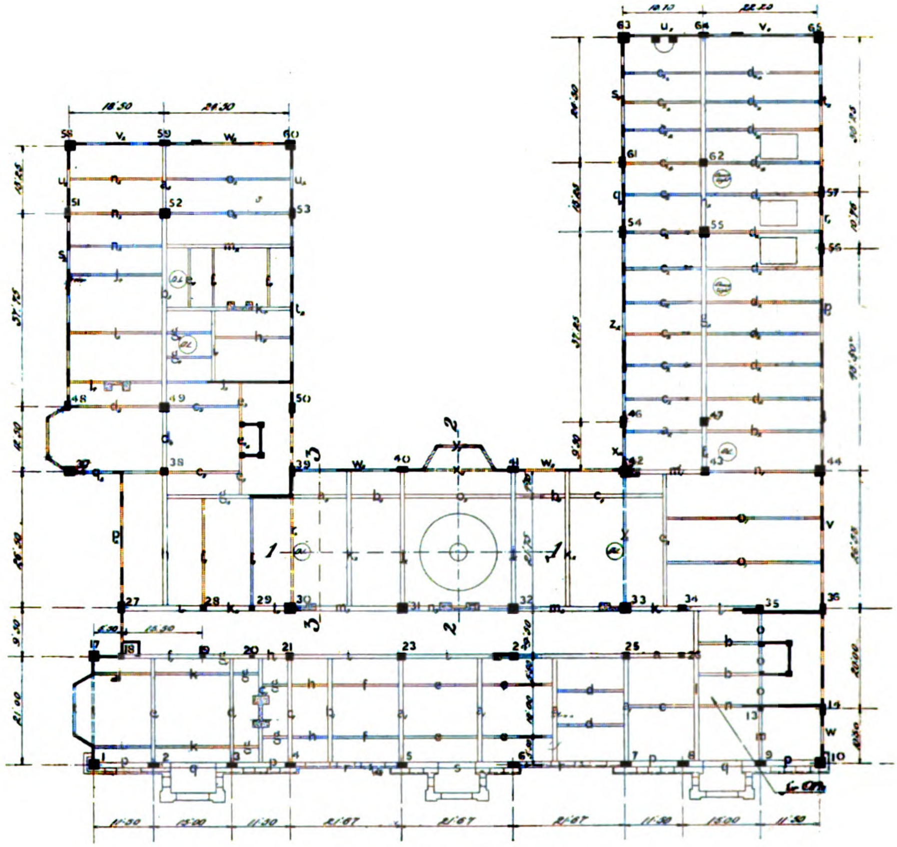


Front Elevation.

REINFORCED CONCRETE IN THE NEW OFFICES OF THE METROPOLITAN RAILWAY.

For reasons of better economy and efficiency, the new offices have been constructed partly over the various lines of railway. This, however, has necessitated a considerable amount of forethought in the planning of the structure, in order not to interfere with either the existing or future traffic.

Various firms of specialist reinforced concrete engineers were invited to compete for the general scheme in this material, and, after very careful consideration of the merits of each particular system, the Coignet system was selected for the preparation of all the plans and technical information required for placing the work in competition amongst contractors accustomed to reinforced concrete construction, and also for the preparation of all the working drawings.



Ground Plan of First Floor.

Reinforced Concrete in the New Offices of the Metropolitan Railway.

A certain number of contractors competed upon the selected scheme, and ultimately the execution of the work was given to Messrs. Henry Lovatt, Ltd.

The reason for adopting this method of procedure was in order to obtain the best possible results, both in design and in the actual execution of the work. The plans and the supervision of the reinforced concrete work were entrusted to Messrs. Edmond Coignet, Ltd., of 20, Victoria Street, Westminster.

The photograph which we reproduce shows the front elevation, which was carried out in brickwork and special faience forming a facing to the reinforced concrete work.

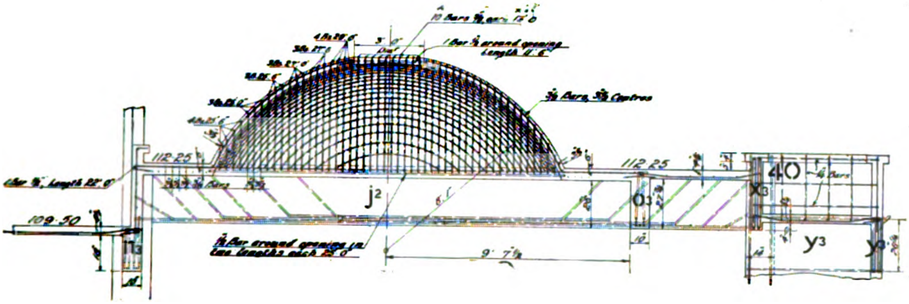
The architectural front on this building was designed by the Engineers' Architectural Assistant. It will be noticed that some of the decorative features—

namely, the bronze buffers and couplings, wheels and signals—clearly denote the association of this building with the railway.

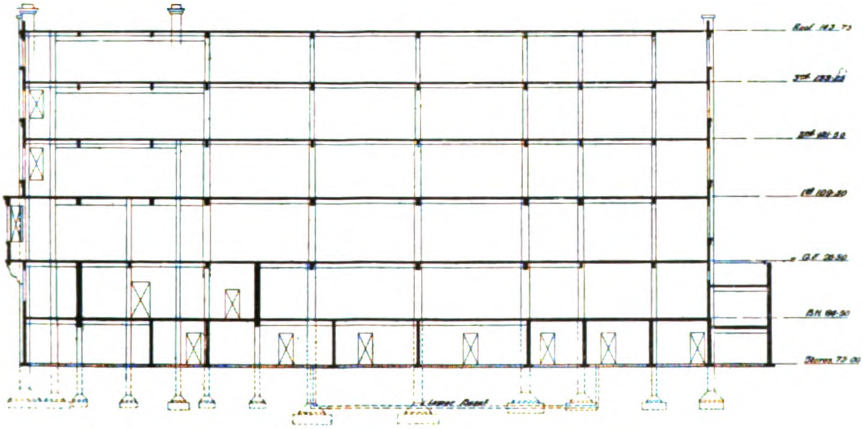
The back elevation, however, constructed over railway lines, has been designed with great simplicity, partly for the sake of economy and partly owing to the fact that this portion of the building is practically hidden from view by the roofs over the platforms.

The total length of the front elevation is about 140 ft., and the total height (measured from the foundations to the roof) is approximately 90 ft.

The back portion of the building is composed of two wings, measuring respectively 111 ft. in length by 38 ft. in width, and 100 ft. by 43 ft. for the smaller wing. The latter is connected to the booking-hall of the new station, facing Marylebone Road, by a steel footbridge. A retaining wall in reinforced concrete has been constructed along the front on a length of 152 ft. and with a height of 24 ft. This retaining wall has been provided to form the basement of the structure, and it is arranged so as to allow the proper lighting and ventilation of the lower portion of the building, below the upper ground level.



Section of Board Room Roof.



Section.

Reinforced Concrete in the New Offices of the Metropolitan Railway.

The building comprises a lower basement, basement, booking-hall floor, ground floor, first, second, and third floors, and a flat roof. A superload of 150 lb. per sq. ft. has been allowed up to the first floor level, inclusive.

The upper floors are calculated for a superload of 90 lb. per sq. ft., and the flat roof for a superload of 40 lb. per sq. ft.

The total superficial area of the various floors and roofs in reinforced concrete amounts to approximately 65,000 sq. ft.

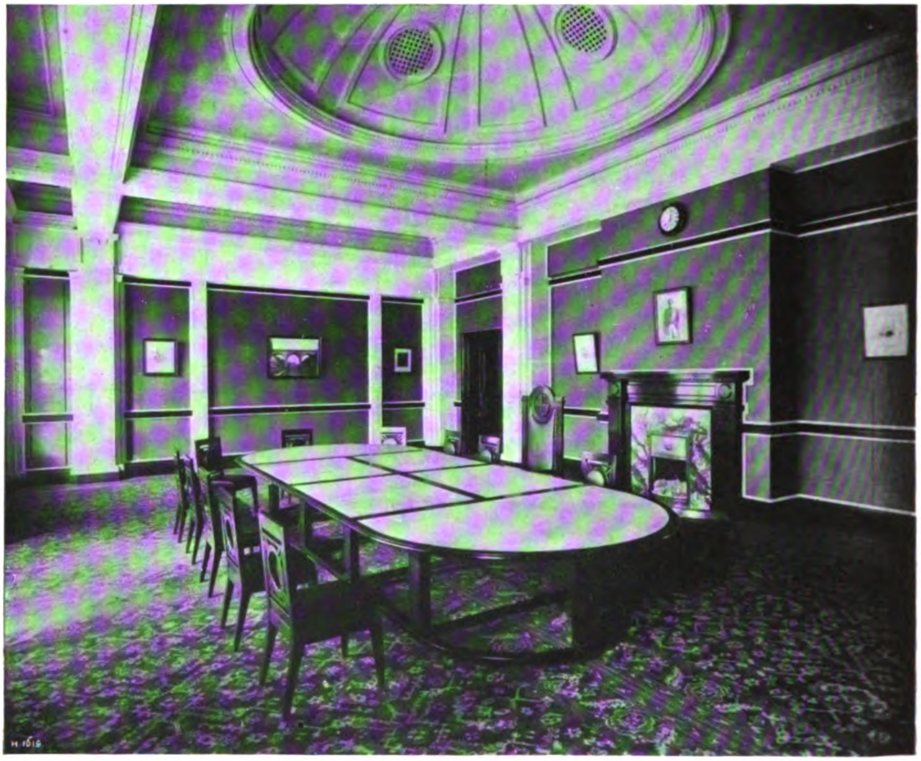
The ground floor at street level is for the accommodation of the principal suites of offices and the board room, of which a photograph is herewith reproduced. This board room is provided with a dome in reinforced concrete.

It is situated between two committee-rooms, and, by a special arrangement of disappearing partitions, it can be enlarged to hold the meetings of the company.

These rooms are panelled in hardwood, with double partitions and windows to shut out any noise from the railway below.

The engineer's office is placed in the north wing, so as to get the maximum amount of light for the drawing-offices.

The two back wings of the building are supported by massive reinforced concrete pillars and beams over the new platforms.



View of Board Room.
REINFORCED CONCRETE IN THE NEW OFFICES OF THE METROPOLITAN RAILWAY.

The lowest floor of the building is on a level with the booking-hall of the new station.

The heating chamber, store, and strong-rooms are situated at a lower level and alongside a set of rails, to facilitate the handling of the coal for heating purposes, also for the handling of stores.

The staircases have automatic lifts. The lift on the south side is arranged to descend to platform level for the purpose of collecting and despatching cash, tickets, and documents.

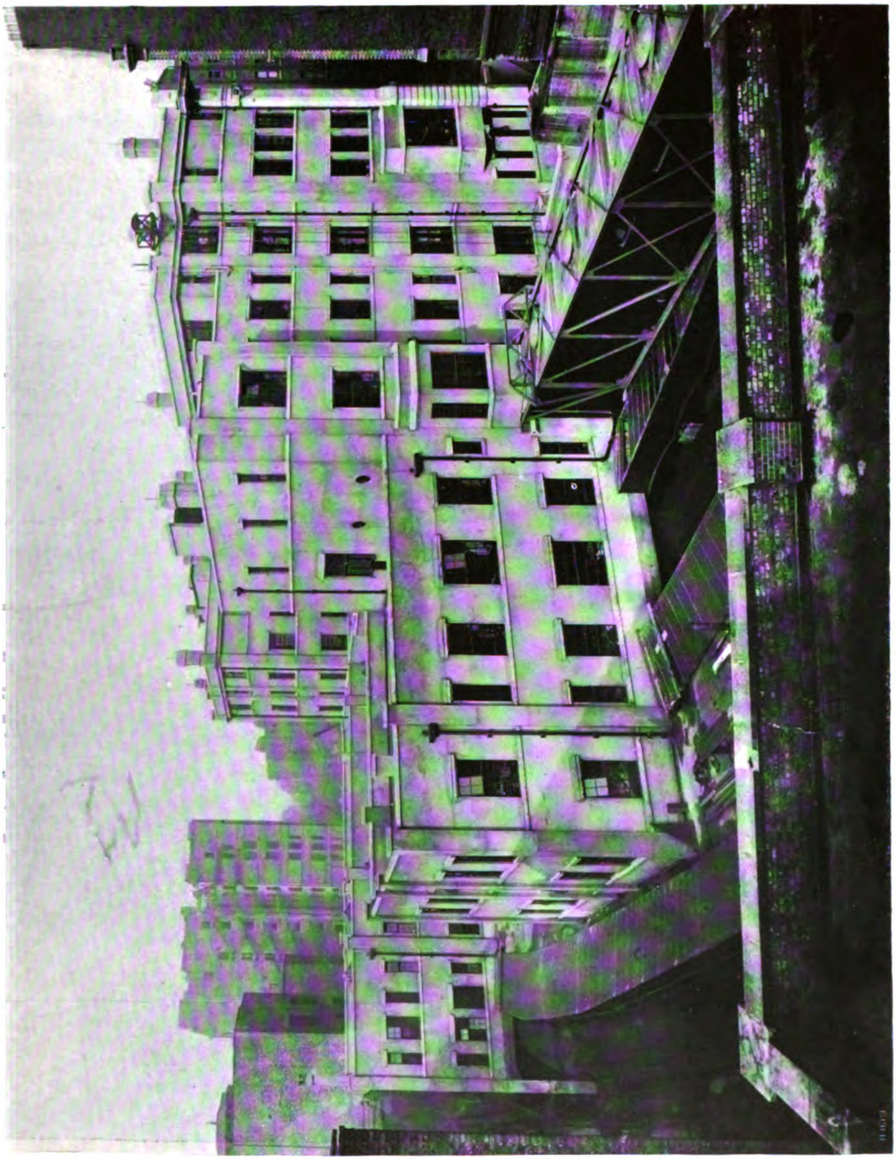
The north staircase lift is connected with the accountant's and other departments. The lift descends to the strong-rooms in the basement.

The kitchens, dining-rooms, and caretaker's quarters are all situated on the top floor.

The entire building is heated by means of radiators with low-pressure hot water.

The floors are covered by means of wooden blocks.

The company's engineer for the work was Mr. W. Willox, M.Inst.C.E., his assistant, Mr. C. W. Clark, having carried out the architectural work, and his resident engineer being Mr. O. G. C. Drury, A.M.I.C.E.



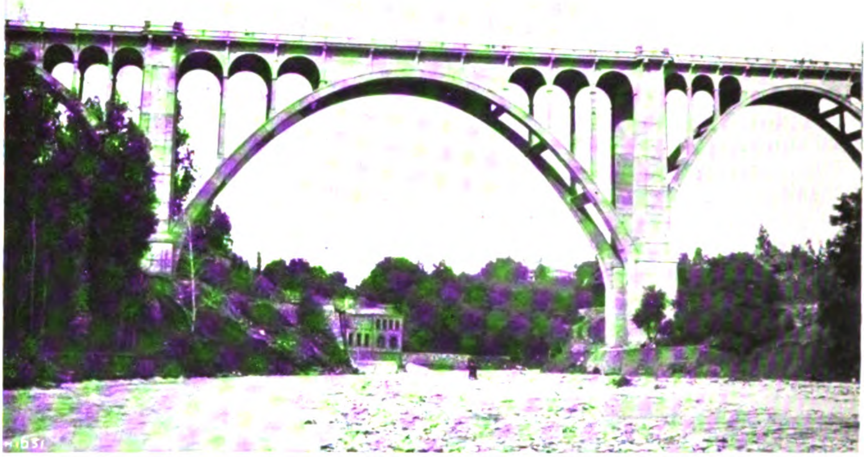
Back Elevation.

Reinforced Concrete in the New Offices of the Metropolitan Railway.

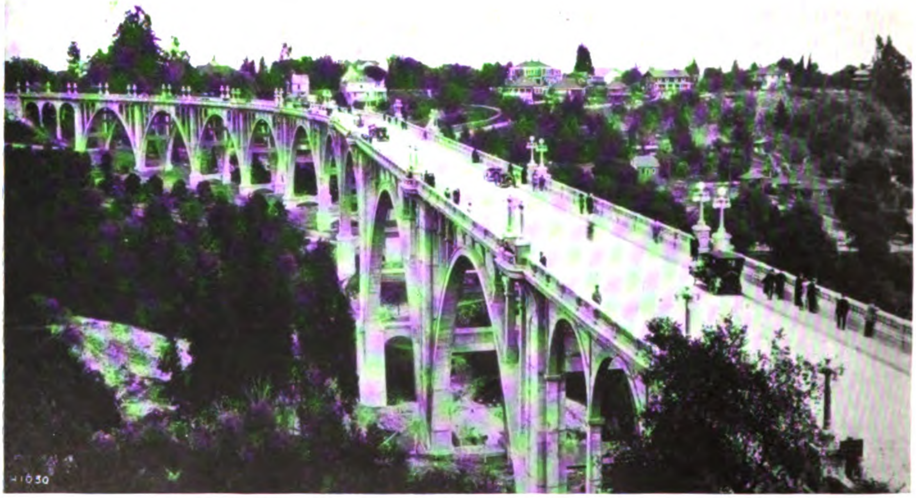
The lifts installed are those of Messrs. Waygoods, Ltd., and Messrs. Beavan and Sons, Ltd., supplied the radiators.

REINFORCED CONCRETE BRIDGE IN CALIFORNIA.

The bridge here illustrated was built jointly by the City of Pasadena and County of Los Angeles across the Arroyo Seco. The work of construction was started in June, 1912, and the bridge was accepted and dedicated in December, 1913. The contract price was $187,700, and the cost of construction, including extras and engineering fees, was approximately $202,000. The total cost, including rights of way, heavy

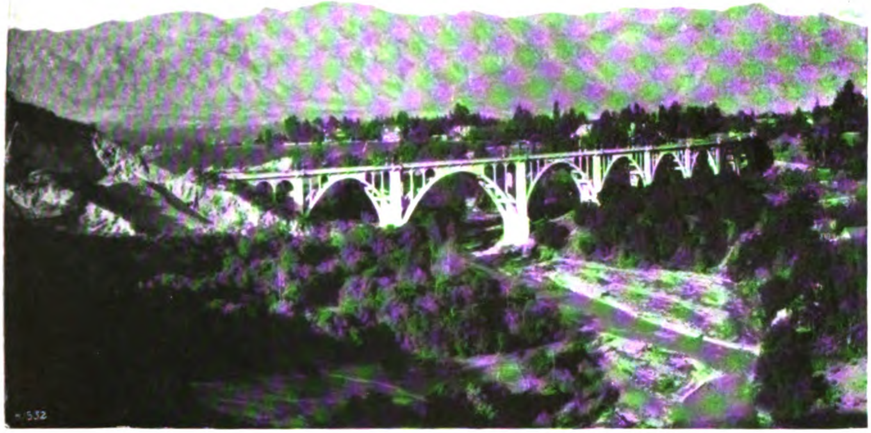


View showing Main Span.



View taken from West-end of Bridge looking towards Pasadena.
Reinforced Concrete Bridge in California.

cuts, and constructing boulevard by the County to connect with the west end of bridge, was $240,000. There are eleven main spans, with a total length of 1,467·5 ft., including approaches. There is a 38-ft. roadway with 5-ft. sidewalks on each side. The longest span, which is directly over the bed of the Arroyo, is 223 ft. from centre to centre of piers, with a height of 150 ft. above the bed of the Arroyo. As will be noted in the accompanying illustrations, the bridge was built partly on a curve. This was done in order to obtain the most economical point for crossing the main part of the Arroyo and avoiding a large expense for piers. The bridge was designed by Messrs. Waddell and Harrington, of Kansas City, Missouri, who also had entire charge and supervision of the construction. The Mercereau Bridge and Construction Company of Los Angeles, California, were the contractors for this work. We are indebted to Mr. Lewis E. Smith, the City Engineer of Pasadena, California, for our particulars and photographs.



View of Bridge looking North,
REINFORCED CONCRETE BRIDGE IN CALIFORNIA.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"A Text-Book of Elementary Building Construction." By Arthur R. Sage and Wm. E. Fretwell.

London. Methuen & Co., Ltd., 36 Essex Street, W.C
293 pp.+viii. Price, 3/6 net.

Contents. — Introduction — Brickwork — Masonry—Iron and Steel—Carpentry —Slating—Plumber's Work—Joinery —Joints, etc., in Pipes—Sanitary Appliances and their Connections—Board of Education Examinations.

There is a great need for a really good text-book on Building Construction which could be given into the hands of a student with the confidence that he would be able to do really useful study and acquire sufficient knowledge to form a groundwork of sound construction and enable him to proceed to the more advanced work almost unaided by personal tuition. Such a text-book could only be prepared by someone who had been in actual contact with students of all kinds, and we are pleased to note that the authors of this volume are both lecturers at the Brixton School of Building, and as such they must be well acquainted with the class of reader to which their book is presented. We are glad to see that notes on materials have been introduced, as these are absolutely essential, and there is no justification for leaving this part of the subject out of an elementary work, as the student must understand the nature and limitations of the various materials before he can fully appreciate their application to building problems. There are various criticisms we should like to make, particularly with regard to some of the diagrams, but space will not permit this, and after all, it must be admitted that it is easier to criticise than produce a perfect work.

There do not appear to be any notes on plastering or painting, and this is to be regretted, as it would have made the volume more complete. Generally speaking the book is well written and should appeal to elementary students, while the price is so small that it should be within the reach of all readers and thus become popular as a text-book for class purposes.

"Portland Cement Manufacture" (Die Portland-Zement-Fabrikation). By Carl Naske.

3rd Edition. 496 pp. and 408 illustrations. 1914. Leipzig
Theo-d. Thomas. Price M. 22.

This excellent handbook has now reached a third edition. Its general features are well known, and have been retained, the only entirely new section being a short one on the quarrying of the raw materials. The principal methods of manufacture, and the machinery and plant employed in the process, are very clearly described, and illustrated by means of clear sectional drawings, the latter being a welcome relief from the reproductions of photographs from makers' catalogues which commonly do duty in works of this kind. The progress of the industry since 1908, the date of the last edition, has been so rapid as to necessitate the re-casting of several sections dealing with crushing and grinding, transport and storage, and the removal of dust. On such subjects as these the book is a mine of information.

The brief section on testing has received less attention than the remainder of the book, and would not be found adequate by workers in this country. On the other hand, the official specifications now occupy 100 pages, and include all those which are now accessible from Japan to Chili. This section will be found useful by many.

INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

CONCRETE PILES.

The system of making concrete piles by driving a tube with a shoe into the ground, leaving the shoe behind, filling the tube with concrete, and then withdrawing it, as protected by John Potter in 1864, is well known, and the system herein described has been devised with the object of obtaining more satisfactory piles by compelling the concrete to effectually fill the void created by the withdrawal of the tube, and it is the invention of Mr. T. W. Ridley, of Messrs. Thos. D. Ridley and Sons, Middlesbrough.

The first part of the patent refers to the joint between the preparatory tube and the shoe, which is a double or triplicate one made by a quantity of Tuck's or other like packing and clay on each side of it. This packing is put underneath the bottom of the preparatory tube and in the recess in the shoe, with the clay on each side, as shown in *Fig.* 1. By very simple arrangements the tube and the shoe can be temporarily connected together, so that, like an ordinary timber or concrete pile, they form one piece.

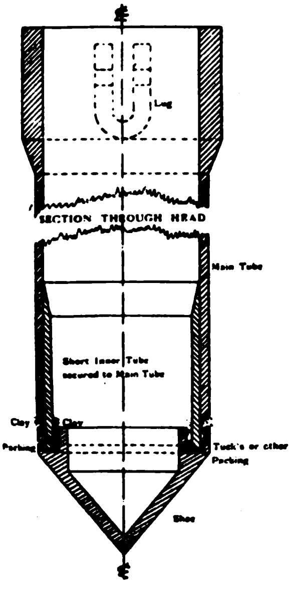


Fig. 1.

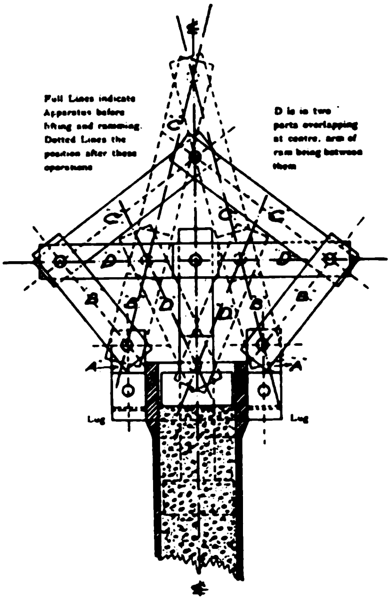

Full Lines indicate Apparatus before lifting and ramming. Dotted Lines the position after these operations
D is in two parts overlapping at centre, arm of ram being between them
C
C
C
C
D
D
B
B
B
B
D
A
A
Lug
Lug

Fig. 2.

The second part relates to the withdrawal of the tube and the compression of the concrete at the same time. This is done by a series of links fixed to the top of the preparatory pile, shown on the drawing in *Fig.* 2. The apparatus is first lifted or raised above the driving head of the tube by two links (*A*), which are fastened to the tube by lugs cast on each side. To *A* are pinned two links (*B*), and these again are pinned to each of the two pairs of links (*C* and *D*). Between the links *D* is fixed a ramrod, which is in the form of a tube with a piston on the end. When the lifting power is applied at the top, where the links *C* meet, *B* and *C* tend to come in a straight line, and the links *D* are depressed and so force down the ramrod, which then causes the concrete to be forced downwards as the tube is lifted. The compressing force practically equals the resisting power or the suction of the ground or friction on the tube in withdrawing it; and as the tube approaches the top it may be necessary to increase the compressing power by clamping the tube to the piling frame, making the tube more difficult to draw, but giving the necessary compressing force on the concrete.

For the foundation of a bridge at Seaton Carew, Messrs. Ridley were allowed to use this pile, on the condition that they satisfied the designers that the concrete adequately filled the hole made by the withdrawal of the tube. Two piles were driven and afterwards dug out. The tube used was 13½ in. internal diameter, and in no case was the column left in the ground less than 15½ in., while where the foundation was peaty the column was nearly 20 in. With this system it is claimed that it is also possible to form a foundation having a reinforced cast concrete column inserted in the preparatory tube, in which also is placed a quantity of fine liquid concrete; then by means of the compressing arrangement this column is forced down into the shoe, and the liquid concrete will, as the tube is withdrawn, take the place of the metal of the tube and thoroughly surround the cast concrete column.

The latter method is used in connection with works in water, and in such cases the shoe and tube are temporarily connected, as previously described, making the watertight joint, and this shod tube is then driven down to the necessary depth and the two are disconnected. When this is done, liquid concrete of very fine material is placed in the tube, and the previously moulded cast concrete column inserted, the latter having upon it a flange which is an easy fit inside the tube. This column is forced down by its own weight or other easy means until the liquid concrete has risen to the underside of the flange. The withdrawal of the tube and compressing will then be worked in the usual way. The cast concrete column will thus be forced down into the shoe, and the liquid concrete will follow the tube up to the ground line, and form a ring or collar of concrete around the cast concrete column, and fill up the hole in the ground. When the tube has left the ground, the surplus concrete, if any (and there should be sufficient to form a surplus), will be left close to where the flange is. In this manner a reinforced concrete pile—reinforced and designed purely and simply for the load it has to carry—can be inserted in the ground and made secure without being damaged in any way by driving, the only difference being that there is a flange at or about the ground line. The function of this flange is to act as the ramrod or the compressing force, causing the liquid concrete to rise out at the bottom of the tube and up around the column itself as the tube is lifted.

As an example, the following particulars are given for a foundation pile about 30 ft. long, using a 14-in. internal diameter tube, which would eventually leave a column about 16½ in. diameter, in the centre of which would be a cast concrete reinforced column 11½ in. diameter. The units are the superficial inches multiplied by the length in feet. This may be perhaps more readily understood than bringing the figures down to cubic feet.

		Ft.	Sq. in.	Units.
Finished pile	30 ft. long × 16½ in. diameter	=30	× 213	=6,390
Finished cast concrete column ...	30 ft. long × 11½ in. diameter	=30	× 104	=3,120
Finished concrete case	30 ft. long × 16½ in. - 11½ in. diameter	=30	× 213—104	=3,270
Contents of preparatory tube ...	30 ft. long × 14 in. diameter	=30	× 154	=4,620
Difference between cast concrete column and contents of tube 30 ft. each	30 ft. long × 14 in. – 11½ in. diameter	=30	× 154 – 104	=1,500

Therefore 3,270 – 1,500 will be needed to insert in the tube before the cast concrete column is placed in position; 1,770 ÷ 154 gives nearly 12 ft. in length of tube. This gives practically two-fifths of the length of the pile. The foreman driving a pile, which in this case is 30 ft. long, would know that he has to put into the tube 12 ft. of its length of fine liquid concrete.

Then the cast concrete column would be allowed to settle by its own weight or that of the tackle to ensure the concrete rising up to the piston, which piston can be either the ordinary piston or one specially cast on the column, as in river or water work. If there was not a sufficient quantity of liquid concrete to do this, more would have to be inserted until the flange was reached. Then the ordinary pressing arrangement and withdrawal would be set to work, and the compression would take place. A pile 30 ft. long should only have to be forced by the compression about 12 ft. One of 40 ft. would have to be forced about 16 ft., while one of 20 ft. would only need about 8 ft. of forcing. The other portion should sink by its own weight.

In the case of a column in river work, where the pile itself is not to be forced down below the ground, the flange would have to be made at or about the ground line, and the liquid concrete all put in, as it could not be passed below the flange after the column was inserted.

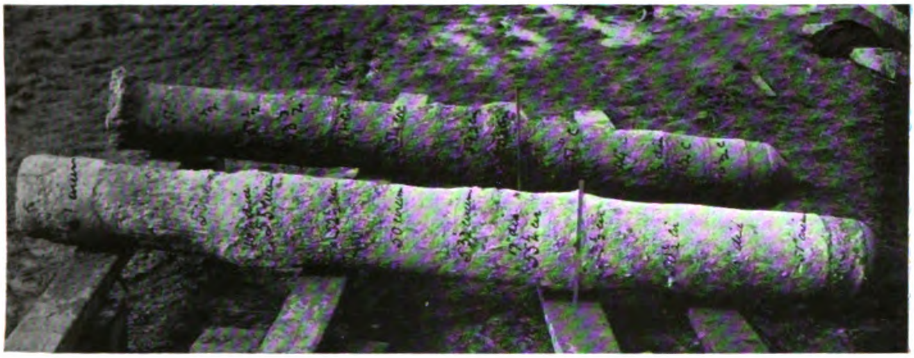


FIG. 3.

The photograph illustrated in *Fig.* 3 shows two piles that have been formed according to this system, and afterwards excavated; and it will be noticed that the fine liquid concrete has spread out in the soft strata and increased the diameter of the pile, thus achieving the inventor's object in compressing the concrete during the withdrawal of the tube.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Iron and Steel Institute.—We are asked to state that the annual meeting of the Institute will be held, by kind permission, in the new house of the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, May 7th and 8th, commencing at 10.30 a.m. each day. Full particulars can be procured from the Secretary, Mr G. C. Lloyd, 28, Victoria Street, S.W.

Liverpool Architectural Association.—A paper was recently read before the above Association by Mr. John A. Davenport, M.Sc., on "Concrete and Reinforced Concrete Don'ts for Architects." After some preliminary remarks dealing with concrete, centering, and steel, the author went on to deal with the subject of fire resistance and economical design. In connection with the subject of fire resistance the author stated that the fighting of fires was the work of municipal authorities, but appliances should always be available to deal with an outbreak on the spot.

Fireproof walls, roofs, and partitions should be used to prevent spreading, but these would be of little use if the coverings to window, door, and other openings were not as strongly resisting as the rest. After localising the fire, attention must be paid to the protection of all structural members, whether built of steel, wood, or stone, and the best material to use is concrete. But the protective coat must be of uniform thickness for best results, and this prohibits the bedding of pipes, ducts, etc., therein. The object of the coat is the protection of the steel, and therefore there must be no passage for the heat to flow from the outside to the inside by way of wood plugs, metal projections, and so on.

Turning to the subject of economy in design, the lecturer said that economy depends upon cost of materials and cost of labour, which will vary from time to time; but these may be taken at present-day values for comparisons. Neglecting all question of architectural economy, the cost of the engineering structure is affected chiefly by the lay-out or arrangement, next by the relative amounts of concrete, steel, and timber, and also by the shapes of the sections used. The most economical job is given by the use of thin slabs supported by beams of shod span, the whole being reinforced with steel of percentage slightly higher than the theoretically economical percentage. Uniformity of sizes makes for economy, as with dissimilar sizes much time is taken in learning to put in the steel and concrete expeditiously. Other things of importance to economical design are the choice of suitable and cheap aggregates, and the adoption of steel sizes which can be purchased cheaply and be worked and handled easily.

A list of concrete and reinforced concrete don'ts bearing on the points raised in the paper was given, and views of reinforced concrete failures, the pulling-down of a reinforced concrete building, and the erection of reinforced concrete buildings were shown and described. We give below a few of the "Dont's" mentioned :—

Don't use any cement that does not satisfy British standard specification.

Don't use a sand which is coated with clay or contains any material which will affect the setting or strength of the cement.

Don't use coke breeze, brick, or any other porous aggregate when a waterproof concrete is wanted.

Don't mix the concrete too dry; a wet mixture is much easier to work.

Don't let any time elapse between the mixing and laying of the concrete.

Don't use any batch after it has commenced to set.

Don't lay concrete in frosty weather.

Don't leave bags of unused cement on the ground and exposed to the weather.

Centering Don'ts.

Don't have weak centering.
Don't forget that the moulds should be cleaned out before the concrete is laid.
Don't leave centering up so long that it delays hardening.
Don't forget to give a little camber to beams of long span to compensate for deadweight deflection.
Don't construct forms for deep work in such a way that the concrete must be poured in from great height.

Steel Don'ts.

Don't use a steel that does not comply with the British standard or the 2nd R.I.B.A. Report Specifications.
Don't allow steel to be welded.
Don't allow concrete to be laid before steel has been seen in the moulds and approved.
Don't let steel be displaced when the concrete is rammed.
Don't let steel be exposed to atmospheric or any other rusting influences.
Don't allow the steel to be bent or worked hot if it can be avoided.

Fire-resisting Don'ts.

Don't omit fire-resisting partitions in any building.
Don't leave unprotected openings in walls, windows and roofs.
Don't leave any structural members unprotected.
Don't leave wood plugs in the protective coatings, as these are easily burnt out and expose the interior.
Don't embed pipes, mains or ducts in the coating.
Don't allow a thickness of coating of less than 1 in.*
Don't use a porous concrete without covering the steel with a rust preventive.

Some Tests on Strength of Overwet Concrete.—Some data have been compiled by the Committee on Specifications and Methods of Tests for Concrete Materials, of the American Concrete Institute, in connection with an extended investigation into a standardisation of concrete test pieces, regarding the deleterious effect of too much water in concrete. While the tests were made in an effort to arrive at a proper proportion of water to use in mixing test pieces, they at the same time went to show definitely the effect of a variation in water content which must be of similar, although not necessarily proportionate, importance in field work.

The tests reported were made under the same prescribed conditions of standardisation and manipulation, but with necessary local variations in material, by three college laboratories. The concrete was approximately a 1 : 2 : 4 mix, with coarse aggregate of from ½ in. to ¾ in. in diameter. Each value given is an average of four 6-in. diam. by 6-in. cylinders. The amount of water used varied with conditions of sand and gravel, but the consistency is described as follows in the Committee's report :—

> Because of the difference in the effect of different sands upon the consistency, it was impossible to specify a definite percentage of water. Tests made by members of the Committee indicate that the most uniform degree of consistency can be obtained by adopting the Chapman consistency test, which consists in filling a slightly tapering cylindrical form with concrete, immediately inverting this, and by repeated trials finding the amount of water which will cause the concrete to just begin to slump when the form is removed. A dry mix is, of course, unsatisfactory, while it is almost impossible to describe a very wet mix which will insure uniformity.

Speaking generally, however, the dry mix is about 8 per cent. water, the normal about 9 per cent., and the wet 10 per cent. These percentages, it will be appreciated, are much lower than those required to give similar consistencies in actual concrete work, but the comparison is the same.

The accompanying table gives the actual compressive values up to sixty days and the curve the average of the three laboratories for the three degrees of consistency.

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* In our opinion this minimum is too low.

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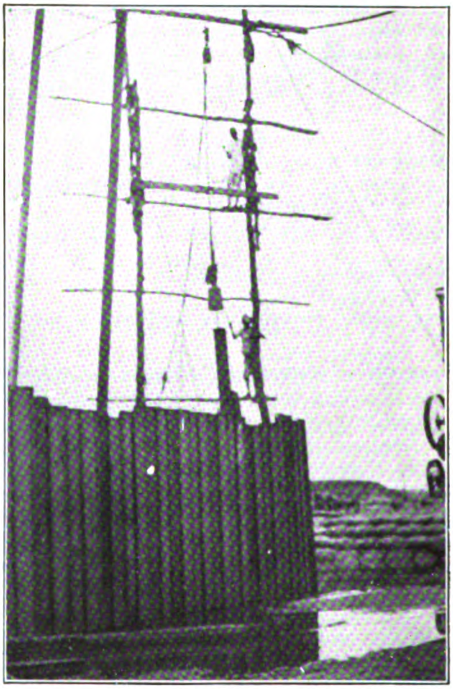

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TABLE SHOWING EFFECT OF WATER PERCENTAGE ON COMPRESSIVE STRENGTH OF CONCRETE 6×6-IN. CYLINDERS.

Average compressive strength, lb. per sq. in.

	University of Illinois.			University of Wisconsin.			Mass. Institute of Technology.		
Age.	Dry	Normal.	Wet.*	Dry	Normal.	Wet.†	Dry.	Normal.	Wet.‡
7 days	1751	1390	1103	1690	1580	533	2047	1740	965
14 days	2140	1775	1354	2795	1905	600	2742	2320	1372
21 days	2658	1816	1623	2450	2095	722	2594	2396	1464
28 days	2615	1820	1657	2380	2430	860	2679	2882	1895
2 months	3056	3063	2410	2485	2340	787	2761	3092	1830

* 10·2 per cent. water. † 12·0 per cent. water. ‡ 10·0 per cent. water.

Reinforced Concrete Telegraph Poles versus Wooden Poles.—The superiority of reinforced concrete for telegraph poles over the ordinary wooden poles has established itself in the recent blizzard in New York. The *Engineering Record* reports as follows: "The storm centre was in and about New York City. The wind blew at a velocity of eighty miles per hour, and there was a heavy fall of snow and sleet. As far as telegraphic communication was concerned, New York was isolated for several days. So severe a load did the ice-coated wires impose upon the concrete poles that the wooden cross-arms on some of them were broken. The poles themselves, however, remained intact." Photographs which accompanied the above report show some wooden poles, after the blizzard, broken right through, whereas an illustration of some concrete poles shows these quite intact, excepting for the damage above mentioned.

Removal of Concrete Forms. — The committee on reinforced concrete of the Canadian Society of Civil Engineers has submitted to the society a draft of proposed standard specifications for plain and reinforced concrete. These specifications contain a clause entitled "Form Removal," which reads as follows:

"The forms shall not be removed until the times named in the following table have elapsed after depositing concrete, not counting periods in which the temperature has been below 35 deg. Fahr."

Part.	Minimum 24-hour day.
Posts under beams and girders	20
Floor-slab panels	10
Wall forms	2
Column forms	4
Sides of beams and girders	4
All other parts	10

—*Engineering Record.*

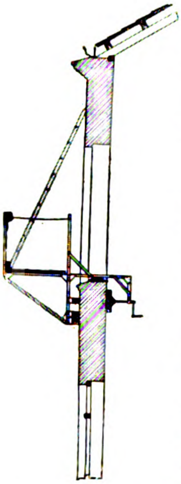
Concrete Dwelling-House at Norwich.—We are asked to state that the concrete block dwelling-house at Norwich for the foreman engineer at the Norwich Main Sewage Pumping Station, and illustrated in our April number (page 285), was built of "Winget" blocks made on "Winget" machines, installed by the Norwich Corporation some time ago.

TRADE NOTICES.

Martin's Adjustable Scaffold Brackets.—Our attention has been drawn to some patent scaffold brackets, of which we give an illustration herewith.

These brackets, which are made of steel throughout, are largely used in place of the ordinary scaffolding, built up from the pavement and swing cradles hung from the roof.

It is claimed that they are extremely light, yet very strong, and can be fitted by unskilled labour in two or three minutes; they can be used for any number of jobs, and when not in use can be stored easily, as each single bracket is only 4 ins. wide.



They are fixed, at any window opening, from the inside of the building, by means of square threaded steel screw and handle, the wood blocks which clamp against the wall being padded with thick felt.

Double brackets, about 2 ft. 6 ins. wide, are made with fixed wood platform and handrail complete, and are suitable for working at a fixed position.

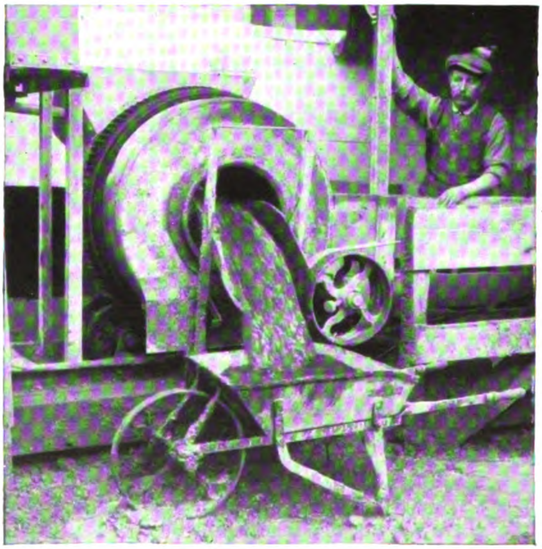
Single brackets may be fixed at each window of a building, and scaffold boards laid from one to the other, thus providing a continuous platform along the front of same.

It is claimed that these brackets entirely save the cost of expensive scaffolding, cradles, etc., and so easily pay for themselves on the first work for which they are used.

The sole manufacturers are Messrs. E. A. Reed and Co., Ltd., of 14, Victoria Street, Westminster, S.W., who will be pleased to send full particulars and prices upon application.

Asbestos Cement Tiles and Boards.—It is claimed for these boards that they are extremely useful as permanent centerings in certain concrete constructions. Once the old-fashioned wood centres are removed, the work has generally to be faced up with cement and sand. Where asbestos cement sheets are used the wood centres may be spaced wide apart, and the asbestos cement sheets put in situ with joints inside the wood centre, splashed on the back with strongly gauged cement and sand to form a good key, and the concrete put in behind, so that when the wood centering is removed a finished surface remains. The boards can also be used for partitions, ceilings, linings, etc.

Full particulars regarding these sheets, etc., can be obtained from Jos. Robinson and Co., Ltd., London, agents for the Carlisle Plaster and Cement Co., Ltd., Carlisle Chambers, 10, Crooms Hill, Greenwich.



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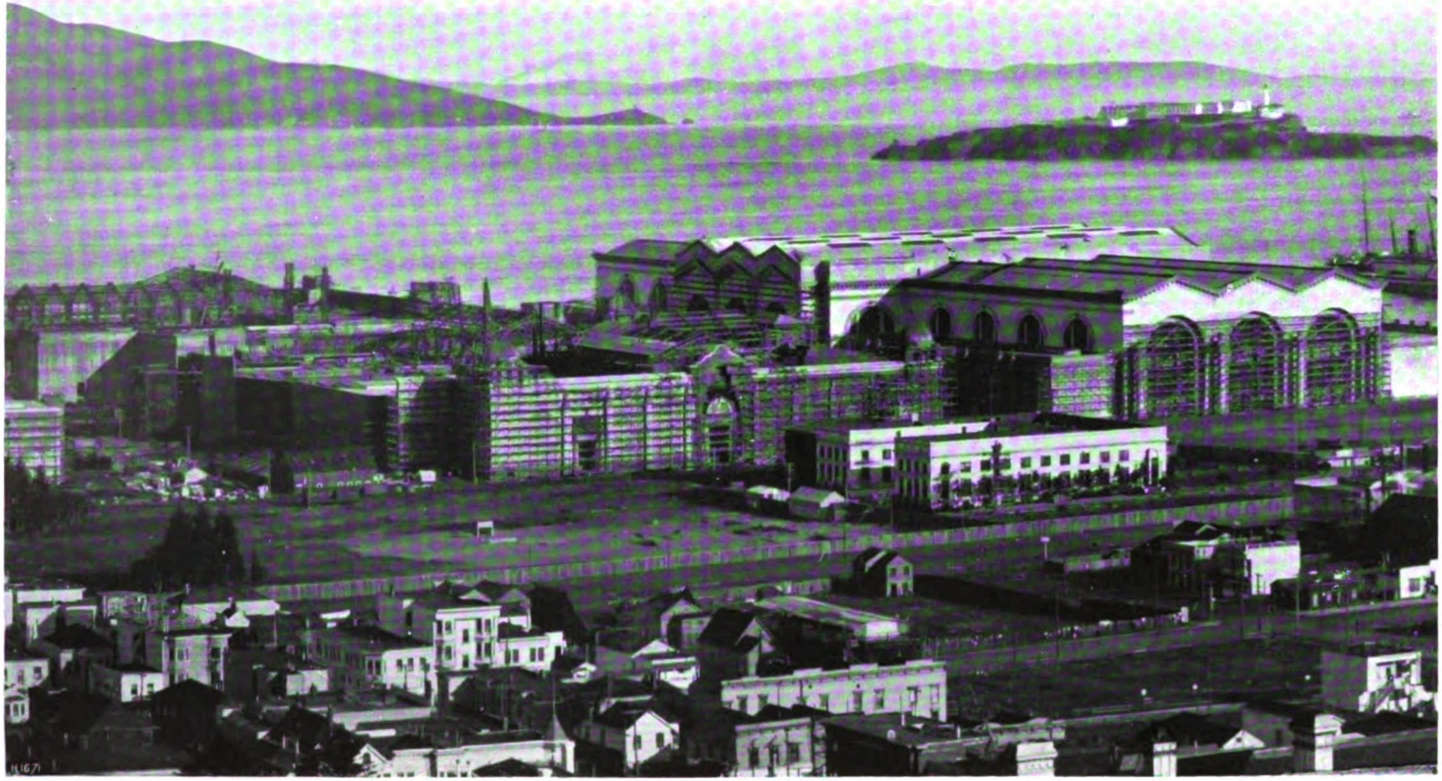


From a Panoramic Photograph by the H. S. Crocker Co.

The Mines and Metallurgy, Varied Industries and Machinery Palaces
THE PANAMA-PACIFIC EXPOSITION.

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume IX. No. 6. LONDON, JUNE, 1914.

EDITORIAL NOTES.

THE CONCRETE INSTITUTE.

The Council's Annual Report, 1913–1914.

THE Council of the Concrete Institute have presented their Annual Report, and a summary thereof, with copious extracts, will be found in another column.

The L.C.C. Reinforced Concrete Regulations.

The first point to note in the report is a matter of congratulation—namely, that the Institute's Council and Committees have devoted a considerable amount of time to consider thoroughly questions regarding the London County Council's General Powers Bill of 1909 as far as it relates to reinforced concrete. Whatever may be the outcome of these deliberations there is not the least doubt that the work has been done painstakingly with the best of possible intentions, and the recommendations of the Institute may be looked upon as an equitable compromise between those who wish to over-police reinforced concrete and those who wish reinforced concrete to have little or no restriction.

Work of Technical Committees.

The second feature of the report is that some of the technical committees of the Institute have been doing a fair amount of useful general work, and have before them further important matters for consideration. We only hope that the consideration of some of these subjects will be accelerated, as the all too frequent postponement of even a provisional solution of an important subject becomes wearisome.

As to the work of the various committees, we are surprised to find that the Tests Standing Committee propose nothing very definite as to tests, for it has now a small fund to draw upon—namely, a fund that was specifically ear-marked for testing purposes and reading-room purposes, comprising money which was collected from the existing members who chose to increase their subscription with a view to assisting the Institute in this direction.

The Proposed Examinations.

The third feature is the constitution of an examination board and the arrangement of examinations. In principle, we are entirely against the Institute being recruited by examination and having its membership in the future chiefly based thereon. To our mind, the very last object of the Institute is to draw hard and fast lines and to have a kind of minor specialist examination of admittance. The Institute, to our mind, was primarily intended to bring together the various classes of professional men, and those interested in the great industries concerned who wish mutually to discuss matters appertaining to concrete and reinforced concrete and their constituents, and anything in the way of examination at this stage, with the object of putting those who have passed an examination into a kind of superior class and those very useful members who happen to be at the head of their relative professions or industries -- but have not been examined--into a secondary class is unwise indeed. The scientist, the chemist, the architect, are, apparently, according to the present programme of the Institute, to play "second fiddle" to the young surveyor or engineer, who, by dint of cramming, passes a certain examination, and likewise the captains of industry, who have more actual knowledge, gained in the hard school of experience, than many a so-called professor.

We should have had nothing against an examination for a diploma, indicating knowledge of concrete or reinforced concrete; or, in other words, we have nothing against an examination that would encourage students and junior members of the various professions and industries concerned. But an examination that is eventually to create a class difference in the Institute is, in our opinion, a very sad mistake, and entirely uncalled for in a young institution of this kind. It is no doubt due largely to those who believe in the value of what we consider are unnecessary initials, and we are afraid the Institute has done something to encourage a craving for these emblems of class distinction by so systematically describing its members as M.C.I.'s. Such a policy may bring in new members and funds, but it is nevertheless to be deprecated.

As to the proposed examination itself, we will deal with that more closely at a later date. We think it goes too far.

The "Reorganisation Muddle."

The fourth point, conspicuous in the report, is what we would call for short the Institute's "reorganisation muddle." A party in the Council of the Institute apparently wish to turn it into a minor institution for structural engineers, which is entirely divergent from the primary object of this body. Another party in the Council of the Institute urges a *status quo* in the objects of the Institute, in its Memorandum of Association, and, above all, a retention of its existing title pure and simple, whilst they are prepared to make gradually progressive changes in the articles or rules as the needs of the Institute may require.

We have already pointed to the fact that a new memorandum and a new set of articles were actually "formally" (*sic*) passed at two extraordinary general meetings, without the purpose or the scope of these changes being properly realised by the principal London members and not realised at all by those in the provinces or abroad. Apparently these changes were made in such an extraordinary fashion that they were of no legal value, for even the resolutions, we see, according to counsel's opinion quoted in the report, were improperly drafted. To put it quite plainly, material changes were attempted which would have entirely altered the objects of the Institute and which would have led to the resignation of nearly half its members, and these changes do not even show the redeeming feature of being well considered and properly brought about in accordance with the law of the land. As to what the Council proposes to do may be read in the report. The Council now--by way of compromise--

suggest, that either the proposed change of the general scope of the Institute—as set out by the revised Memorandum of Association of November last—be passed by two further extraordinary general meetings with such additional amendments in the articles as may be requisite, or that the changes attempted in November—which, as a matter of fact, do not legally "hold water" at the moment—be formally rescinded. This compromise at least shows that the opponents to the change are making themselves felt.

To these extraordinary general meetings, of course, the whole of the membership will be called; but, as the Annual Report plainly states, quite two-thirds of them live away from London. These members living out of London are, however, disfranchised, as they have no right to vote by proxy. The result will thus be that, even if the changes were again adopted by a London majority, several hundred of the provincial and colonial members would oppose the change in Court, and we are advised that they would have a very good prospect of succeeding; in other words, to-day's *impasse* would be repeated.

We would thus strongly urge the Institute's Council to go warily in pressing for the proposed change. The society stands a fair chance of being ruined if it adopts the proposed Memorandum—there would be a large secession from its membership and an immediate cessation of its usefulness. On the other hand, if it will go steadily, quietly, keeping its old memorandum, objects and title—only gradually changing the articles as modern requirements may necessitate from time to time—it still has possibilities of getting back the prestige it enjoyed during the presidency of Sir Henry Tanner.

We have been in the closest possible touch with the provincial and colonial members. They resent the proposed changes, and they have no desire to be associated with an institute having other objects than the original ones—namely, to elucidate questions relating to concrete and reinforced concrete and their constituents only. They may be interested in steel frame construction as used in conjunction with concrete, and in concrete as used in conjunction with steel frame construction; but steel frame construction is perfectly well taken care of by that senior of all engineering societies, the Institution of Civil Engineers, and by its existing junior associations. Should an institution for structural engineers really be required (and we believe, as a matter of fact, there is some scheme for one on foot), let those who are desirous of promoting such an institution work out their own salvation. The Concrete Institute has a *raison d'être* and a wide scope, and this wide scope will suffice for the next few decades at least.

Generally.

The last two years of the Institute's work have, as we see from the records, led to a slight increase in the members. But it would almost seem that the Institute has been lately marking time in this respect.

We observe there is a new class of Associate Members already given in the Annual Report, and also a class of Associates, although of course neither of these classes actually exists at the moment, owing to the *impasse* referred to above. In students there has certainly been progress; and this we attribute to the educational talent of the Institute's secretary.

In lecture work the curriculum of the Institute has been prolific and the subjects chosen frequently of considerable interest.

To repeat, however, the leading feature of the Institute for the last year was the work done in trying to get the London Reinforced Concrete Regulations put on to a sound footing, and certain other Committee work.

Unfortunately, however, the good work has been largely discounted by loss of prestige, by dissension within the Institute and within its Council.

If the new president can now by great tact and courtesy, by going slow in any question of change and by quietly improving the administration retain what is to-day left of the Institute's prestige, he will do well and merit the thanks of the membership and of the nation. On the other hand, if he presses any personal views or predilections as to the subordination of concrete and reinforced concrete by according structural engineering a primary position in the Institute, we are afraid he may have to preside at the Institute's funeral.

We have, however, reason to believe that Professor Adams may be spared such a misfortune if he finds it possible to fulfil the assurance he gave at the annual general meeting—namely, that he would use every endeavour to act impartially. Further, one of the vice-presidents, who is so strongly opposed to the proposed change in the original objects of the Institute, and who has some three hundred members with him, threw out a suggestion for compromise that may bear fruit, as the President indicated that he was not disinclined to further such changes in the rules of the Institute as would give the provincial and the colonial member a say in such important matters as are now before that body.

If the opponents of the proposed changes achieve the withdrawal of what to them is an obnoxious revision of the Memorandum of Association and obtain a proper franchise for the entire membership, they, on their part, ought to be ready to assist in the modernisation of the Articles, for they would then have achieved their primary end of retaining the objects and title of the Institute and have given every member a proper say in the development of this Institution.

But, unfortunately, the tension within the Concrete Institute is such, that if the President repeats the blunder of giving offence to a large section of the membership—as he apparently did in his speech at the Institute's recent annual dinner—he may find an immediate secession of another group of members who strongly resent any tendency towards class distinction and may no longer care to be associated with this body in any form. His remarks at this dinner have opened up fresh sources of dissension which it will not be easy to smooth over. We trust, however, that this new source of trouble may also be eventually overcome.

OUR CONCRETE COTTAGE COMPETITION.

Every endeavour is being made by the Assessors to complete their work in judging the drawings sent in for the above competition, so as to enable us to announce the result of same in our July number.

No fewer than 245 designs have been sent in.

H.M. NEW STATIONERY OFFICE.

By ALBERT LAKEMAN, M.S.A.

In our January issue of last year we were able to publish an article on this building in its earlier stages. The following article deals mainly with the superstructure.—ED.

REINFORCED CONCRETE CONSTRUCTION.

THE description given in the previous notes dealt almost entirely with the general plan of the buildings, the steel gantries which were employed during the erection of the work, and the foundation details generally. Owing to the whole of the superstructure being constructed with reinforced concrete, some notes on this part of the scheme should be of interest, and although there is naturally a great deal of repetition in such a large structure, there are features which are somewhat out of the ordinary run of every-day construction. One of the chief of these is provided by the arched beams which carry the building over Bazon Street and connect the warehouse and office portions. This connecting portion is about 40 ft. wide, and the distance between the two main buildings is 27 ft. 6 in., the height extending for three floors, viz., the first, second, and third, giving a total of 31 ft. above the first floor level. The external walls are of concrete, having a minimum thickness of 4 in., and the arched beams occur under these walls below the first floor level, as shown in the drawing illustrated in *Fig. 2*. They have a minimum depth of 2 ft. at the centre, which increases to 6 ft. at the springing points, the thickness being 12 in. The reinforcement consists of six rods on the soffit at the centre, and three of these are bent up towards the top, commencing at a point about 7 ft. from the centre line on

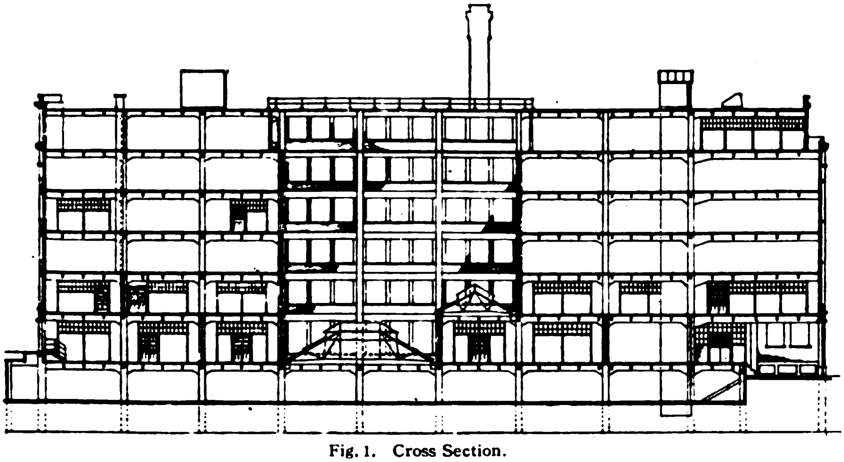


Fig. 1. Cross Section.
H.M. NEW STATIONERY OFFICE.

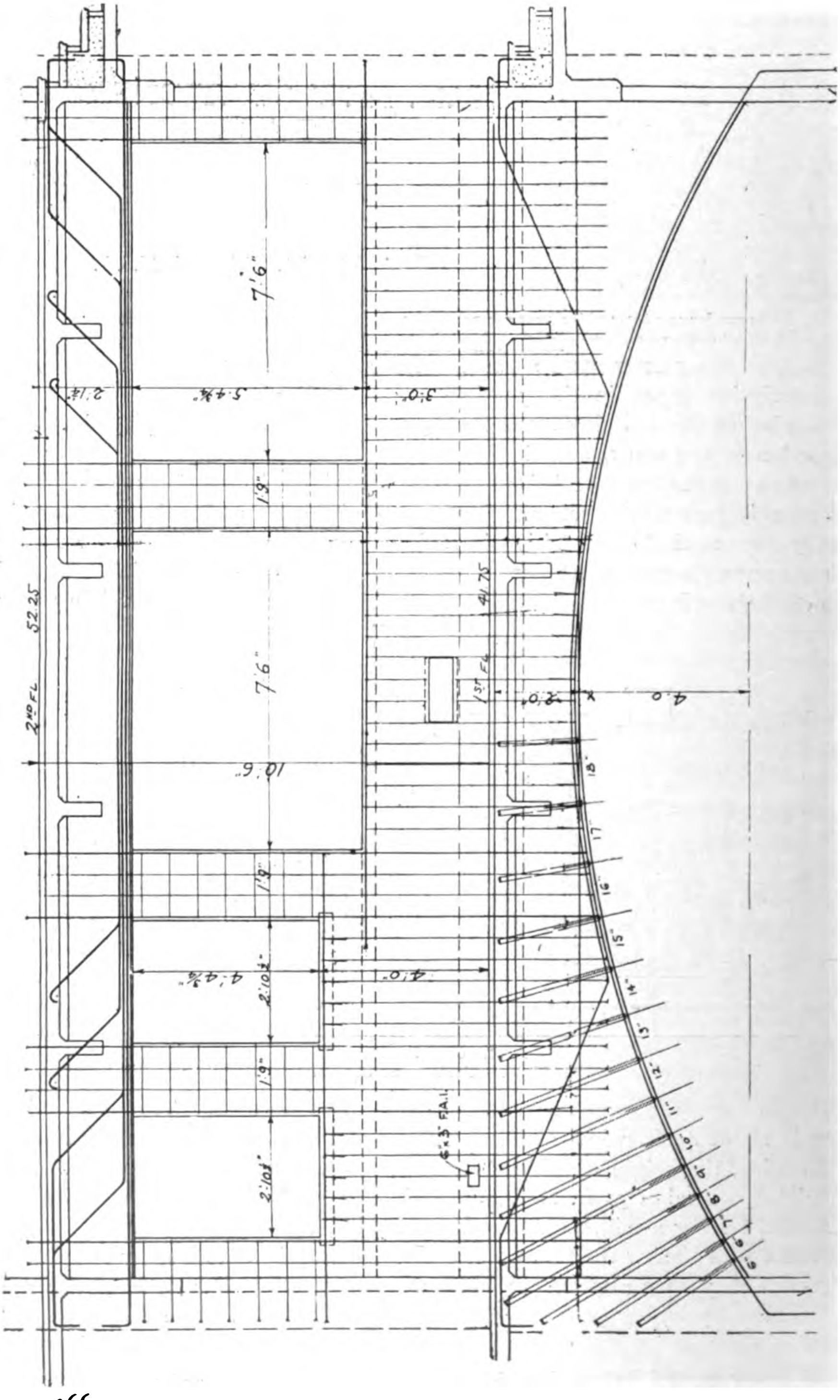


Fig. 2. Elevation of Arched Beam over Bazon Street.
H.M. New Stationery Office.

each side, and the remaining three continue in a line concentric with the soffit, and are carried well down into the supporting members at the ends of the span.

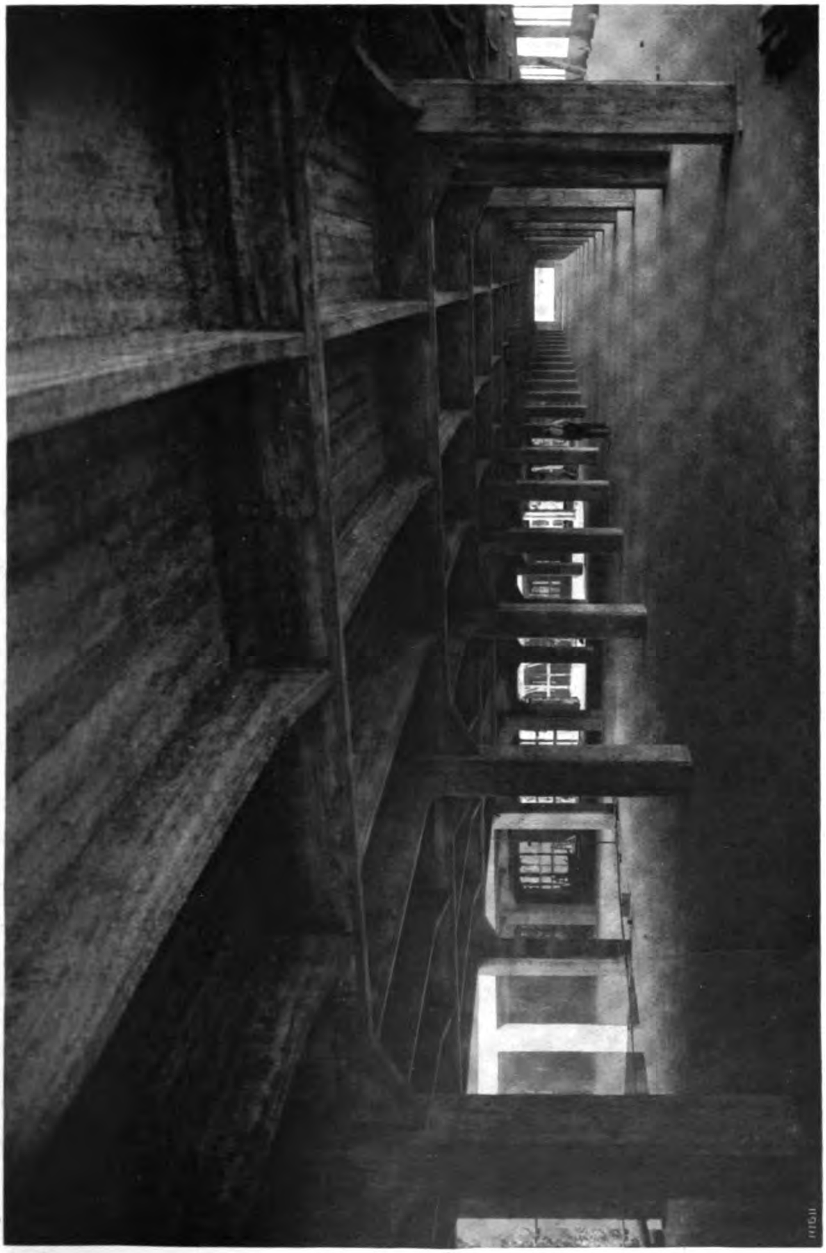


Fig. 3. Interior View of Warehouse.
H.M. New Stationery Office.

Stirrups are provided throughout the length at varying distances apart, as shown on the drawing. A horizontal string course 18 in. deep with a

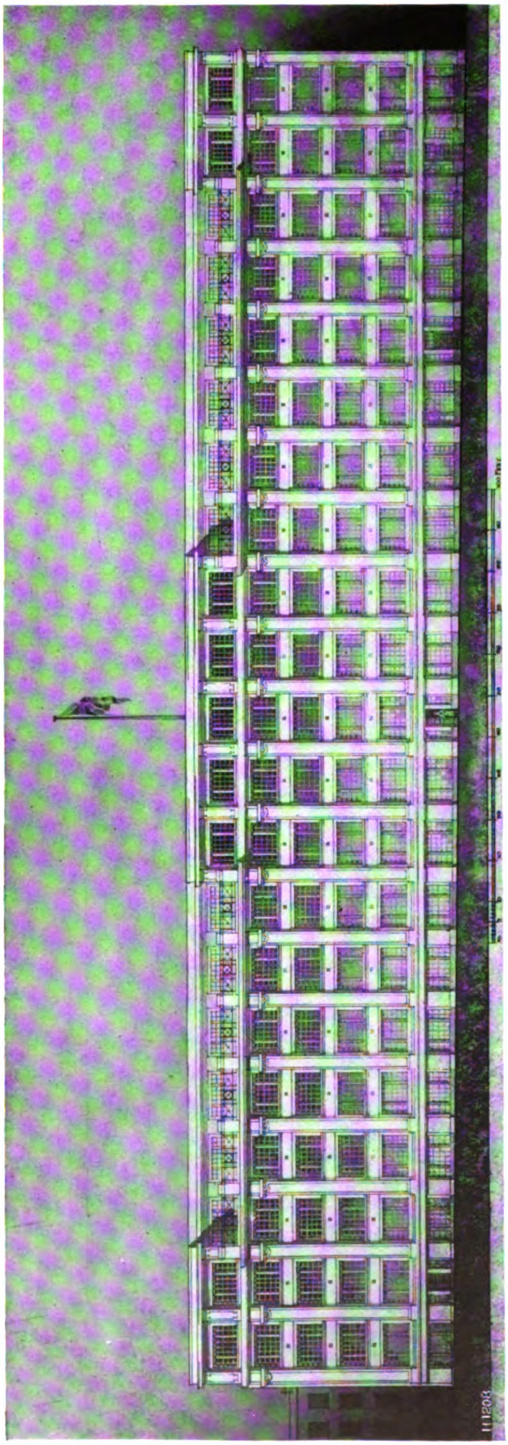


Fig. 4. Elevation to Stamford Street.
H.M. New Stationery Office.

6 in. projection is formed at the top of this beam, and this is also constructed of reinforced concrete. The remainder of the wall is constructed with concrete, reinforced with horizontal and vertical bars, the piers between the windows acting as stiffeners to the horizontal portions, which are designed as deep wall beams, with two rods in the lower surface. These wall beams extend below the floor level for a distance of about 2 ft., and as they take the ends of the floor beams they are increased to 6 in. in thickness for this portion. Short stirrups are provided with these main reinforcing rods, and in addition the vertical rods are bent round them, thus anchoring them to the mass of concrete above. The outer ends of the secondary roof beams are carried by wall beams 3 ft. 4 in. deep, these being formed by carrying up the parapets to the external walls for a height of 1 ft. 9 in. above the roof level. They also have a thickness of 6 in., and the reinforcement consists of two rods in the lower and one in the upper surface, with vertical rods at 6 in. centres bent around both sets.

The floors of this connecting building are divided up into three bays by main beams 24 in. deep and 8 in. wide, with six bars as reinforcement in the tensional area, and each of these has a compression flange 6 ft. wide and 6 in. thick, whereas the remainder of the slabs are only $3\frac{1}{2}$ in. thick. The secondary beams are spaced at

5 ft 6 in. centres, and these have a depth of 12 in. and a thickness of 4 in., with two bars in the lower surface as reinforcement.

The roof is carried by a similar system, but the beams and slabs are all reduced in proportion to the load to be carried, these being 100 lb. for the floors and 65 lb. per square foot for the roof, in addition to the dead weight of the materials employed. Stirrups are provided in all the beams, and these are kinked to clip the main reinforcing bars tightly.

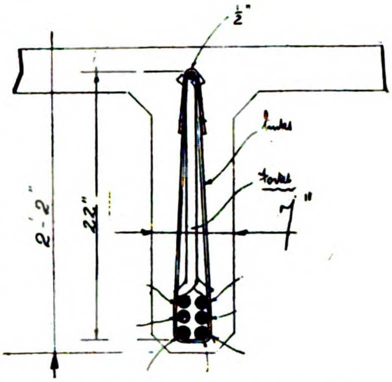


Fig. 5. Detail of Beam Reinforcement.
H.M. New Stationery Office.

The front wall of the main building to Stamford Street is an excellent example of an external reinforced concrete wall, and here the window openings are about 10 ft. wide and 6 ft. high, with piers between 3 ft. 2 in. wide. The minimum thickness which occurs over the windows between the piers is 6 in., and the reinforcement in these portions is provided by horizontal bars in the centre of the thickness and vertical bars in both outer and inner surfaces. The piers generally are 1 ft. 3 in. thick, and they are reinforced with six vertical rods, one being placed at each corner and one in the centre in each surface, with links connecting the whole of the rods. The ends of the horizontal rods in the wall slabs are carried well into the pier, and are lapped for a length of 18 in. Additional rods are also placed around the window openings, and all bars coming against these at right angles are hooked over them, and thus the whole of the reinforcement is well tied together. All projecting mouldings are formed in the concrete, and the reinforcement is varied to suit this by turning out the bars as required, this occurring more especially at the top of the building, where a large cornice and the caps to the pilasters are introduced. There is some interesting work at this point, and the design of the reinforcement exhibits considerable skill in the manner in which it is applied to the various members.

As stated in the previous article, the columns are spaced generally in rows 20 ft. 6 in. apart at intervals of 15 ft. 2 in., and thus the main beams have a span of 20 ft. 6 in. and the secondary beams a span of 15 ft. 2 in. The size of the columns varies from 20 in. square to 24 in. square, with eight to twelve lines of vertical reinforcement well tied in all directions by links spaced at 8 in. centres. The floors have been calculated to carry a super load of 3 cwt. per square foot on the ground floor of the warehouse and 2½ cwt. on the upper floors, while in the office building the allowance is 100 lb. per square foot for all floors, and 65 lb. for the roofs. The slabs are only 3½ in. thick in the warehouse portion and 3 in. thick in the office portion.

The main floors are designed as illustrated in *Figs* 5 and 7, which show a portion of a beam on the ground floor. This has a maximum depth of 2 ft. 2 in. from the top of the slab and thickness of 7 in., with six bars in the lower surface, four of which are turned up towards the ends of the spans to take the diagonal tension, and links are provided which pass round these main bars and also around one small rod which is placed in the upper surface. Continuity rods are also placed in the upper surface where the beams pass over the columns, and haunches are formed at the intersections.

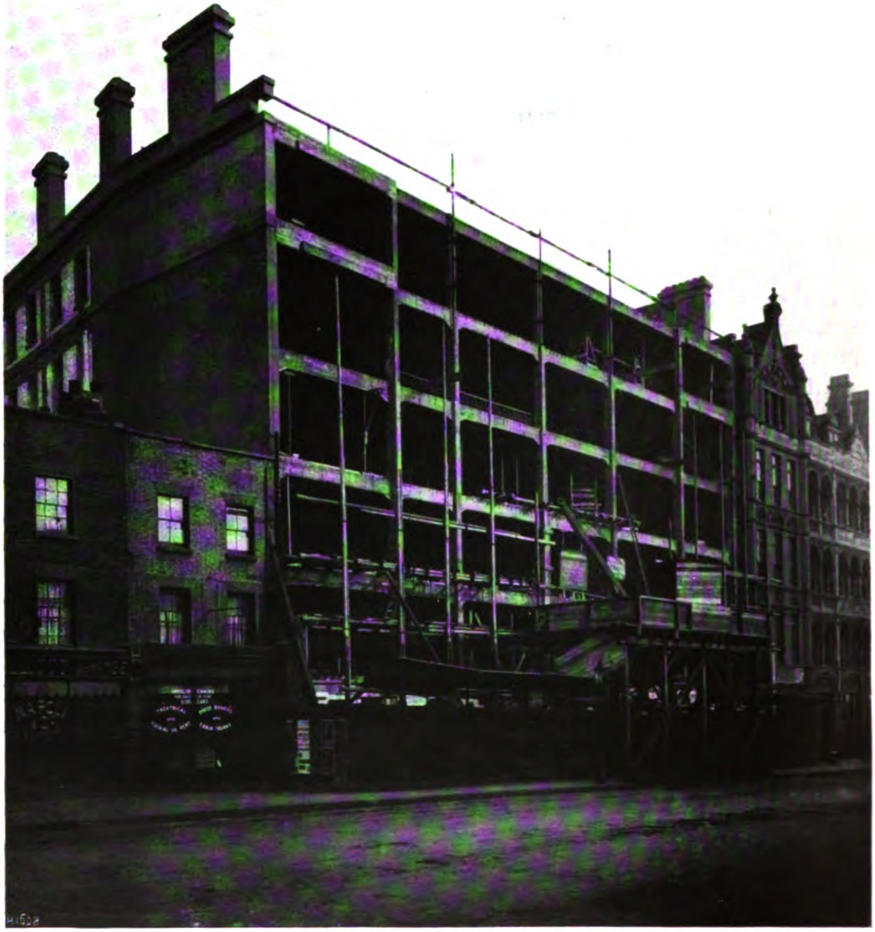


Fig. 6. View of Building on Waterloo Road Side.
H.M. New Stationery Office.

The secondary beams are spaced at 5-ft. centres and these are built up in a similar manner to the main beams. They have a depth of 18 in. and a thickness of 4 in. below the slab, with six bars as reinforcement in the tension area.

The roof beams are spaced in a similar manner to those constructed in the floors, but are of slightly smaller sections in consequence of the lighter loads to be carried. The whole of the reinforcement where possible was built up into complete skeleton form before being placed in the moulds to ensure accuracy and effect economy.

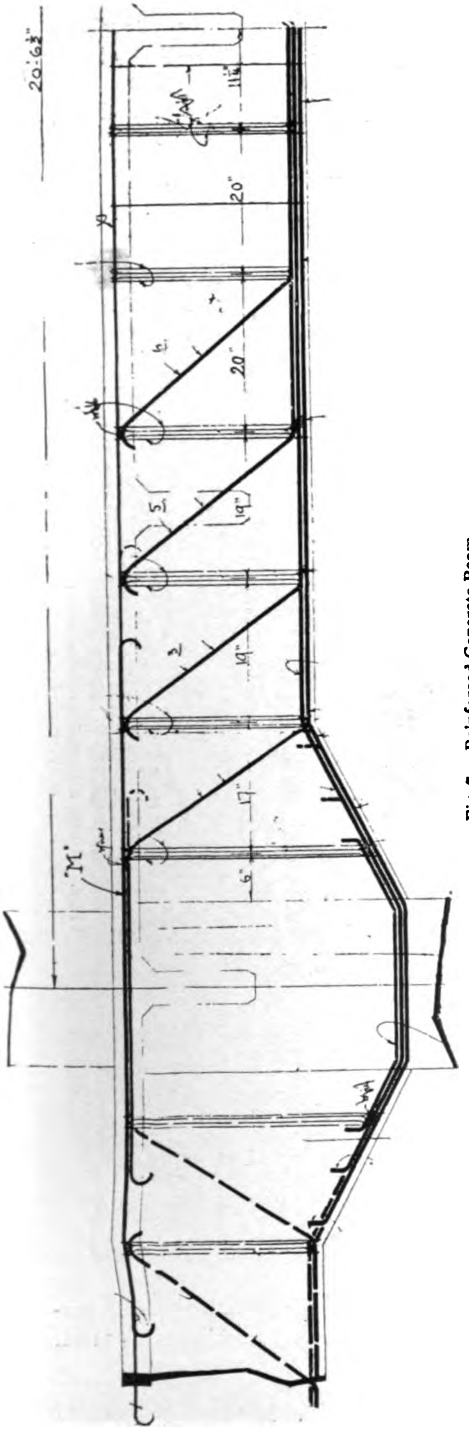


Fig. 7. Reinforced Concrete Beam. H.M. New Stationery Office.

The concrete employed for the columns was mixed with one part of Portland cement, one part of sand, and two parts of ballast, and it will be seen that this is much richer than that usually adopted. The object of this mixture was to be able to allow a greater stress per square inch on the material, and thus a less quantity was required and it is claimed that economy was effected in this way.

The building has points of interest, inasmuch as it is a complete reinforced concrete structure throughout and the policy of H.M. Office of Works in adopting this material is commendable, as the question of fire-resistance is one of the utmost importance in a building of this class. The large area and simplicity of the building enabled a great deal of repetition to be made in the size of the members and thus the materials and centering could be economically designed and used.

ELECTRICAL INSTALLATION.

The electrical installation includes the wiring for lighting purposes and a separate direct current service for the lifts and other power requirements. The system of wiring commences at the main lighting and power switchboards fixed at the east end of the basement; and from the lighting main board separate 19/14 cables run to a central distribution board on each floor of the warehouse block, and from these 7/16 sub-mains to the fuse-boards. The main cables are all paper insulated and lead-covered, whilst the sub-mains are rubber insulated run in galvanised tubing. Generally speaking, the whole of the distributing system of sub-circuits is also run in galvanised tubing, which is placed on the surface of the concrete. Fixings are obtained by means of iron dowels cemented in, and the cutting away for these was executed by the contractors for the electrical work, who installed a special motor-driven air-compressor which drives special pneumatic hammers. The concrete was found to be so hard that hand cutting would have involved very considerable expense and labour. The lamps are distributed evenly over the whole of the warehouse portion, one being provided for each bay of about 15 ft. by 20 ft. and the boards and switches are grouped near the lift wells.

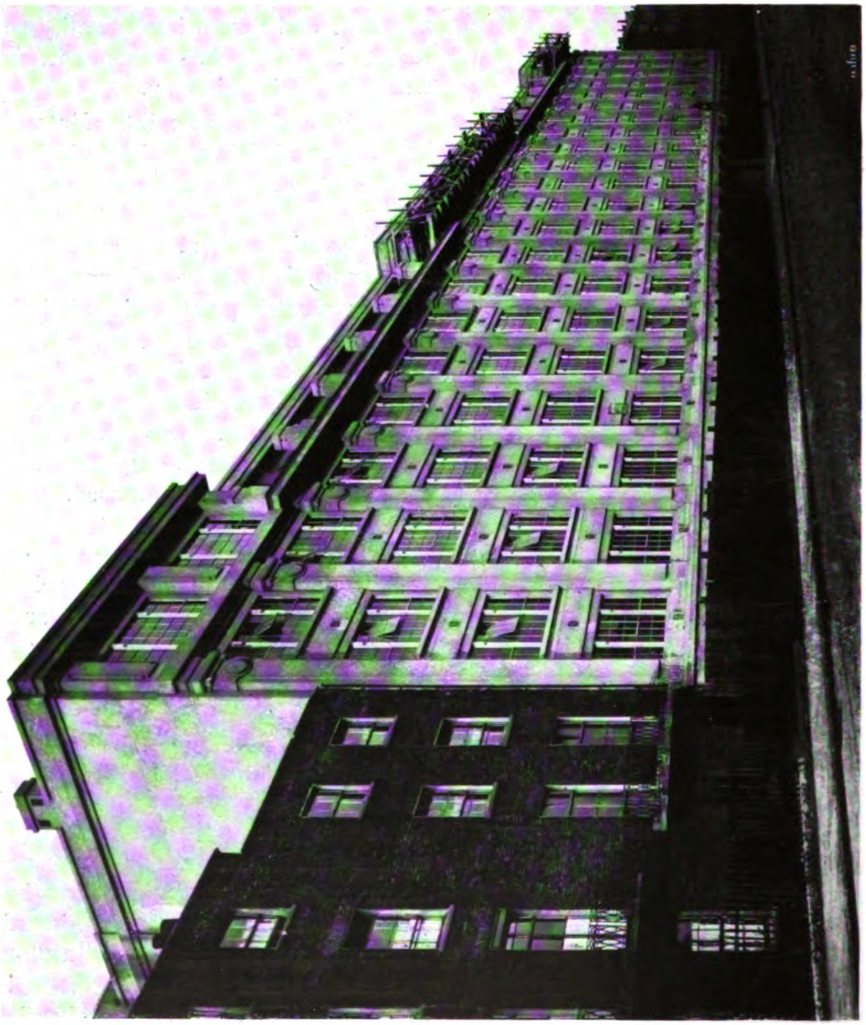


Fig. 8. View of Stamford Street Elevation.
H.M. New Stationery Office.

The building was designed by, and is being carried out under the supervision of, Mr. R. J. Allison, A.R.I.B.A., one of the principal architects at H.M. Office of Works.

The general contractors for the building are Messrs. Perry and Co., Ltd., of Bow, and the whole of the reinforced concrete was carried out on the Hennebique system from designs prepared by Messrs. Mouchel and Partners. The steelwork for the gantries was supplied and erected by Messrs. Drew, Bear, Perks and Co., Ltd., Battersea Street Works, and the reinforcing steel was supplied by Messrs. Dorman, Long and Co., Ltd., of Middlesbrough. The ballast was procured from the Ham River Grit Co., Rochester, and the electrical work is being executed by Messrs. Tyler and Freeman, of 20, New Bridge Street, E.C., to the specification of the Chief Engineer to the Office of Works. The heating installation is being carried out by Messrs. Berry and Sons, of Westminster. The photographs are those of Messrs. Tella Camera Co.

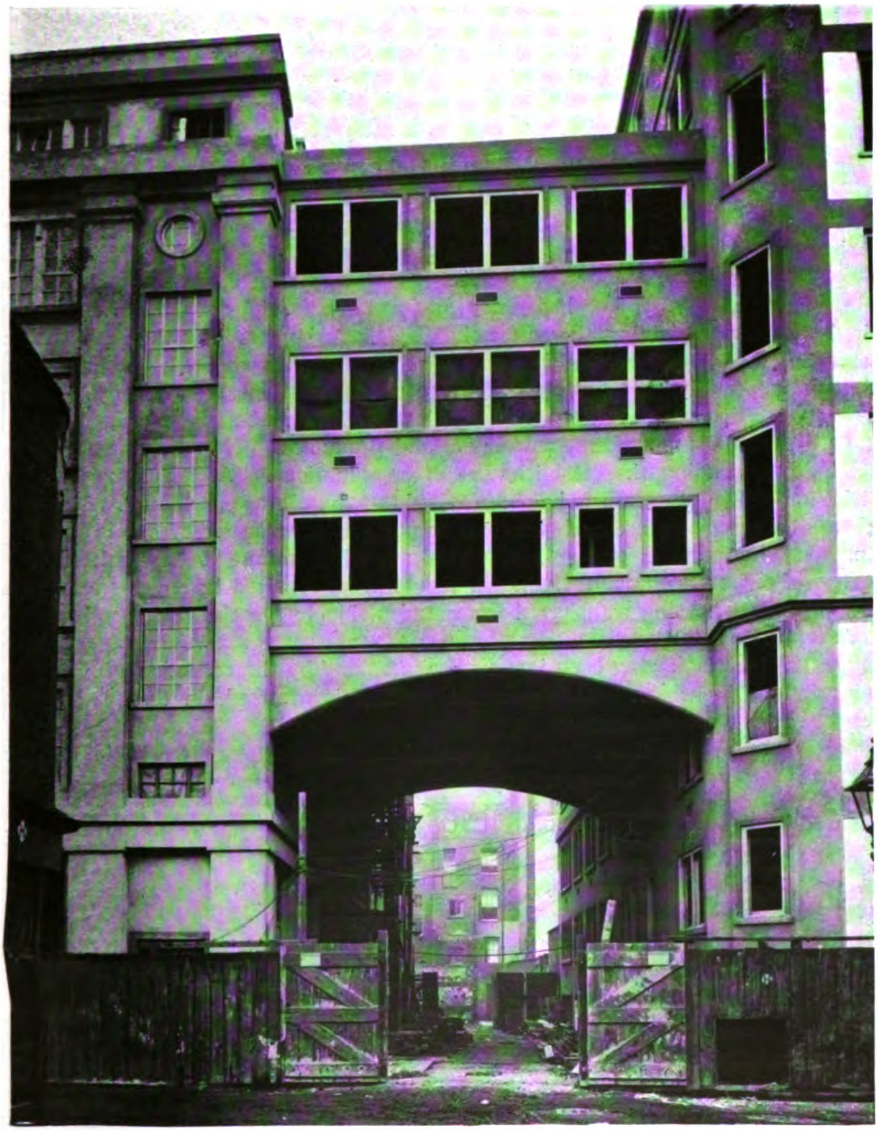


Fig. 9. Arch and Building over Bazon Street.
H.M. NEW STATIONERY OFFICE.

ANNUAL GENERAL MEETING.

The Fifth Annual General Meeting of the Concrete Institute took place on May 28th at Denison House, Vauxhall Bridge Road, S.W., when the Annual Report was put forward. Below we give a summary of the Report.—ED.

A SUMMARY OF THE COUNCIL'S REPORT.

Membership.—The Concrete Institute had on May 14th, 1914, 930 members, 28 associate-members, 6 associates, 54 students, 5 special subscribers, and 16 honorary members, making a total membership of 1,039. Of this total, 360 reside in London and its environs, 364 reside in the provinces, and 315 abroad.

Classification of Members.—The decision of the Council, that when the total membership of all classes reached 1,000 an entrance fee of one guinea should be required of members joining thereafter, has been acted upon. Furthermore, at the beginning of the 1913-14 session, a number of alterations were made in the Articles of Association, with the approval of Extraordinary General Meetings. These alterations, in brief, extended the classification of the membership by the inclusion of classes of associate-members, associates, and graduates. No graduates have yet been admitted, pending the establishment of examinations. At the same time the subscription fee for full members has been raised to two guineas per annum. Associate-members and associates are each required to pay an entrance fee of one guinea and an annual subscription of one guinea. Students will continue to be admitted as at present, without an entrance fee, though they will be required to pay a transfer fee of one guinea upon being transferred from studentship to associate-membership.

Finances.—In the previous annual report a surplus was reported, and attributed chiefly to the income having been increased abnormally by the collection of a number of subscriptions in arrear. This year the position is reversed, in that a deficit of £161 19s. 10d. has been realised.

Meetings.—The number of meetings and educational lectures given in the previous Session was larger than in any earlier Session.

As the result of a ballot among members of Council, the bronze medal for the best Paper read in the 1912-13 Session has been awarded to Mr. S. Bylander, for his Paper entitled "Steel Frame Buildings in London."

Early Copies of Papers.—It having been represented that some members resident in the provinces and abroad, or for other reasons unable to attend the meetings, are desirous of receiving copies of papers read at general meetings in advance of their publication in the *Transactions,* the Council has decided that in future members may receive regularly advance copies of papers upon payment of 5s. annually to cover the cost of postage, etc. The privilege of receiving advance copies will be extended without any such payment to all those members who pay the new rate of subscription in the membership class—namely, £2 2s. per annum.

Meetings of Junior Members.—In the past Session informal meetings of the junior members of the Institute have been instituted. The meetings have so far been held on Friday evenings, the first two taking place on April 3rd and May 1st, 1914. The attendance at these meetings has been very encouraging, and it is confidently expected that the meetings will be of great educational assistance to junior members of the Institute.

The Scope of the Institute.—In former annual reports reference has been made to a "Committee appointed to consider the widened scope of the Concrete Institute," the title of this Committee being subsequently changed to the "Improvements Committee." An abstract of the report of the Committee was appended to the report of the Council for the 1911-12 Session, in which it was stated that the Committee was appointed to take energetic steps to develop the structural engineering side of the widened scope, and that the Committee had defined for the purpose of the Institute that "Structural Engineering" was that branch of engineering which dealt with the scientific design, the construction, and the erection of structures of all kinds in any material. The Committee further defined "Structures" as being those constructions which are subject principally to the laws of statics as opposed to those constructions which are subject to the laws of dynamics and kinematics, such as engines and machines. The Committee unanimously recommended—and the Council subsequently adopted their recommendation—that a sub-title should be added to the Institute, so that the full title should be: "The Concrete Institute, an Institution for Structural Engineers, Architects, etc."

Examinations for the Institute.—The Committee also recommended the institution of examinations in structural engineering. Accordingly, the Council, during the past Session, appointed an Examination Committee, which was subsequently (in December last) merged in a nucleus Examination Board. The Examination Board has compiled a syllabus and rules for the proposed examination, which are appended to this report. It is proposed to hold the first examination next year.

Alteration of the Institute's Articles.—The alterations to the Articles of Association, previously referred to as having been carried at the Extraordinary General Meetings at the beginning of the Session, were made and adopted at the suggestion of the Committee.

Alteration of the Institute's Memorandum of Incorporation.—At the same time, proposals were put forward for the amendment of the Memorandum of Association, whereby the enlarged scope would be more clearly defined, although the Committee had in their original report stated their opinion that Clause 3 (1) of the present Memorandum did not limit the scope of the Institute to concrete and reinforced concrete, but that the clause enabled the Institute to deal with iron (including steel), bricks, gravel, sand, cements, and other structural materials, and their application. The amendment proposed to Clause 3 (1) was as follows, the words to be added being shown in black type, and the words to be omitted by italic type within square brackets:

> 3. (1) To advance the knowledge of concrete and reinforced concrete and **other materials employed in structural engineering,** [*their constituents,*] and to direct attention to the uses to which these materials can be best applied.

Consequential alterations were made in other paragraphs defining the objects of the Institute. Also, in addition, it was proposed to make an alteration consisting of adding the words "and Associate-Member" to the word "Member" in Clause 7, which defines the liabilities of the members, this alteration being suggested in view of the fact that a new class of associate-members was created by the alterations to the Articles.

Action of the Board of Trade.—When the alterations were duly submitted to the Board of Trade, after their approval by the general membership, the Institute was required to give, and gave, an undertaking to apply to the Court for allowance of the alterations to the Memorandum. The Board of Trade raised certain objections however; in particular they objected that the addition of the words "and Associate-Member" was not an alteration of the objects of the Institute, which was the only alteration permissible in the Memorandum of Association, and that only with the approval of the Court. The Institute's counsel has similarly advised the Institute. The Board of Trade raised the further objection that, as the proposed alterations to the objects appeared to have the effect of extending the scope, they were of the opinion that the enlarged scope ought to be shown by an alteration in the title of the Institute. The Institute's counsel has also expressed the opinion that the resolution which was actually passed did not in terms refer to any alteration in the Memorandum of Association, the resolution using the words "New Regulations." Counsel expressed the opinion that the Court might very well take this objection and refuse the order.

Differences in the Council.—Differences have arisen in the Council as to what action the members should be recommended to take so as to put the matter in order before applying to the Court, and the Council has decided to place the following alternative policies before a General Meeting of the Members before going into Court:—

(*a*) To rescind the alterations to the Memorandum and revert to the original Memorandum of Association with the necessary further alterations to the Articles to provide for Associate-Membership.

(*b*) To rescind the alterations to the Memorandum of Association and to repass the same with such additional alterations as may be required to meet the objections of the Board of Trade.

In connection with the second of these policies, the Council regret to find that a misunderstanding has arisen as to the intention of one paragraph out of twenty-five, namely, Clause 3 (2). If the second policy be agreed to, "concrete and reinforced concrete" will be specially and specifically mentioned in the aforesaid clause.

Special meetings for the purpose of deciding between these policies will be convened at the beginning of next Session.

The Institute and the L.C.C.—The Council and Committees have been very much occupied in the past Session with technical matters. In previous Reports the action of the Institute has been recorded in respect to the Regulations made under the provision of Section 23 of the London County Council (General Powers) Act, 1909, with respect to the construction of buildings wholly or partly of reinforced concrete. The Institute made suggestions upon a draft which was submitted by the London County Council, and, subsequently made suggestions upon the first set of Regulations when issued by the London County Council. These suggestions for the amendment of the Regulations were sent to the Local Government Board, and in June, 1913, the London County Council rescinded their first set of Regulations and made new Regulations, which were the outcome of prolonged negotiations between technical advisers of the Council and the Local Government Board. The statutory notice of the intention of the London County Council to apply to the Local Government Board for allowance was duly given to the four Societies named in the Act, namely, the Royal Institute of British Architects, the Institution of Civil Engineers, the Surveyors' Institution, and the Concrete Institute. The second (and revised) Regulations thus came before the Societies for consideration with a view to submitting further suggestions for amendment to the Local Government Board. It was found that, as a result of the negotiations between the technical advisers of the London County Council and the Local Government Board, many drastic alterations had been made to the first set of Regulations, and as the Building Acts Committee of the L.C.C. reported "in some instances they render the Regulations somewhat more onerous than those originally adopted by the Council." The matter is naturally one of extreme importance to the members of this

Institute, not merely as affecting practice in London, but because the Regulations, when finally approved, will probably be referred to by municipalities in promoting Regulations for their respective localities. The Council and the Standing Committees, *i.e.*, the Science Standing Committee, the Reinforced Concrete Practice Standing Committee, the Parliamentary Committee, and the Tests Standing Committee, have, therefore, given careful detailed consideration to the revised Regulations.

The Institute's suggestions as to the amendment of the second set of Regulations were sent to the other technical societies, and the Institute has been informed that they have been supported in large part by the Royal Institute of British Architects and by the Surveyors' Institution. The Institution of Civil Engineers informed the Institute that they had not made suggestions for amendment in detail. The Institute's suggestions were finally submitted to the Local Government Board in December last and are now under consideration by the technical advisers of the London County Council and the Local Government Board.

The Institute's Committees have been so closely occupied with the L.C.C. Regulations that they have not been able to do much other work, though they have a number of subjects in hand for consideration. The details of their work are given below.

New Members of Council.—In June, 1913, Major H. S. Rogers and Mr. Morgan E. Yeatman were co-opted as Members of Council.

President and Vice-Presidents.—In accordance with the Rules of the Institute one Vice-President has to retire every two years, in order of seniority. Accordingly, Mr. Edwin O. Sachs retired and was re-elected a Vice-President in November, 1913.

Mr. E. P. Wells's term of office as President expiring in May, Professor Henry Adams was appointed President for the ensuing two years. The appointment of Professor Adams as President created a vacancy among the Vice-Presidents—who are required to number five—which the Council decided to fill by the appointment of Mr. H. D. Searles-Wood as Vice-President. This will create a vacancy among the ordinary Members of Council.

The following Members of Council have resigned during the past year :—Mr. E. J. Lovegrove and Mr. Henry Tanner. The foregoing vacancies among ordinary Members of Council have not yet been filled.

The Late Mr. W. G. Kirkaldy.—The Council deeply regret to record the decease of Mr. William G. Kirkaldy, an esteemed Member of Council, Chairman of the Tests Standing Committee, and one of the representatives of the Concrete Institute on the Joint Committee on Reinforced Concrete conducted by the Royal Institute of British Architects.

Finance and General Purposes Committee.—The Finance and General Purposes Committee has held regular meetings preliminary to each Council meeting, and the general results of their deliberations are contained in the foregoing particulars of the Council's work for the year.

Science Standing Committee.—In addition to considering the L.C.C. Regulations for Reinforced Concrete, the Science Standing Committee has been concerned with the revision of the Standard Notation for Structural Engineering Calculations, in view of the criticisms made at the General Meeting when the draft report on the matter was submitted. The finally revised notation will be issued shortly. In conjunction with the Reinforced Concrete Practice Standing Committee a Standard Specification for Reinforced Concrete work has been prepared in draft and will be submitted for discussion at a General Meeting next Session.

The Science Standing Committee has the following further matters under consideration :—

1. Standardisation of joints and connections in reinforced concrete.
2. Advice to Superintendents of reinforced concrete work.
3. Amendment of the Standard Specification for Cement.

4. Co-ordination of the Standard Specification for structural steel of all kinds.
5. The adhesion of and friction between concrete and steel.
6. Reinforced concrete piles.
7. The effect of sewage upon concrete.
8. The effect of oils and fats on concrete.

Reinforced Concrete Practice Standing Committee.—During the past Session the Reinforced Concrete Practice Standing Committee has met, in conjunction with the other Standing Committees and the Council, to consider the L.C.C. Regulations for Reinforced Concrete Work. The Committee has held joint meetings also with delegates of the Quantity Surveyors' Association, and with members of the Concrete Institute who are Quantity Surveyors by profession. Several meetings were held, as a result of which a draft report on a Standard Method of Measurement for Reinforced Concrete was submitted for discussion at a General Meeting. Since this meeting, the report has been considered by the National Federation of Building Trades Employers of Great Britain and Ireland and by the Institute of Builders, who have made suggestions for its amendment in certain particulars. Meetings will be subsequently convened to consider the various criticisms and steps taken to issue a final report in due course.

The Committee has prepared, in conjunction with the Science Committee, a draft Standard Specification for Reinforced Concrete Work, as recorded above.

The Reinforced Concrete Practice Standing Committee has the following further matters under consideration :—

1. Advice to clerks of works, inspectors and foremen as to methods of properly executing concrete and reinforced concrete work and of preventing defects and failures.
2. Regulations, recommendations of Joint Committees, and various methods of calculation in respect to the design of reinforced concrete and the like
3. Forms and centering for reinforced concrete work.
4. Standard concrete mixtures for general purposes.
5. The use of cinder, ash, clinker, and breeze in concrete.
6. Means of keeping reinforcements in place when concreting.
7. Methods of making concrete watertight and of waterproofing concrete.

Tests Standing Committee and Parliamentary Standing Committee.—The Tests Standing Committee and the Parliamentary Standing Committee have held joint meetings with the Council and the other Standing Committees, as previously mentioned.

The Tests Standing Committee has the following matters under consideration :—

1. The effect upon steel of the presence of sulphur in aggregates.
2. The grading of aggregates.
3. The expansion and deterioration of concrete due to changes of atmospheric temperature.
4. The effect of the use of sodium silicate on the surface of concrete as affecting reinforcing metal.
5. The erratic results obtained by the Vicat needle in ascertaining the initial setting time of cement.
6. The collection of data regarding the elastic moduli of concrete for stresses within working limits.

Investigation Committee.—The Investigation Committee has held meetings at which have been considered (*a*) the action of the Local Government Board in respect to the periods allowed for the repayment of loans sanctioned by them to Local Authorities for the construction of works of reinforced concrete; and (*b*) reports of failures of reinforced concrete structures. In connection with the latter, a Standard Report Form for the use of observers of defects and failures has been drawn up.

Joint Committee on Loads on Highway Bridges.—The Joint Committee on Loads on Highway Bridges, conducted by the Concrete Institute, has been engaged in the drafting of its report, but it is not yet completed. It is expected that it will be ready for presentation for discussion at a General Meeting next Session.

Attached to the Report, in form of an Appendix, were given the Rules and Syllabus of the proposed Examination, and we give below particulars of same, as follows :—

APPENDIX.

Rules of the Examination.

The Examination is divided into two parts:—

Part I. Scientific (for Graduateship), consists of written papers dealing with the scientific basis of the subject.

Part II. Technical (for Associate-Membership), consists of written papers and *vivâ-voce* examinations, dealing with the technology of the subject.

The examination is held half-yearly in May and October.

1. The age of the candidate at the date of examination is not restricted.

2. A candidate may enter for Part I. alone, and if successful he may take Part II. at a subsequent Examination. A candidate is not permitted to present himself for Part II. unless he has passed Part I., or one of the Examinations (see below) which are accepted by the Council in lieu of Part I.; but a candidate may enter for Parts I. and II. together.

In Part II. a candidate must enter for two at least of the subjects, one of which must be Structural Engineering. The subject or subjects in which he is successful will be named on the Certificate.

3. The Examination is confined to Students and Graduates of the Institute.

4. Candidates exempted from Part I. may be registered as Graduates without passing that part of the Examination, but no Certificate will be issued.

5. Applications to be admitted to either or both parts of the Examination must be made on the prescribed form, must be received by the Secretary not later than one month before the date of the Examination, and must be accompanied by the necessary fee.

6. The fee for either part of the Examination taken separately is £1 1s. (One Guinea). If the two parts are taken at one time the fee for the whole Examination is £1 11s. 6d. (One and a Half Guineas).

7. Each applicant will be informed when he has been accepted as a candidate, after which the fee will be forfeited if he does not present himself at the Examination for which he has entered.

8. Every candidate who qualifies in, or is exempted from Part I. of the Examination, will, on passing Part II., be granted a Certificate of having passed the Associate-Membership Examination. On passing Part I. a Certificate of having passed the Graduateship Examination will be granted.

9. The fact of passing the Examination does not exempt a candidate from the other requirements for election in accordance with the Articles and By-laws of the Institute.

10. Candidates are required to attend at the Examination Room fifteen minutes before the hour fixed for the first paper to be taken by them.

11. Drawing and mathematical instruments, including slide-rules, may be used. The use of books will not be allowed in Part I., but in Part II. candidates may bring and use text-books and note-books.

The following will be exempt from the requirement to sit for Part I. of the Examination.

(*a*) Bachelor of Science.
(*b*) Bachelor of Engineering.
(*c*) Associate Member of the Institution of Civil Engineers (by examination).
(*d*) Associate Member of the Institution of Mechanical Engineers (by examination).
(*e*) Associate of the Royal Institute of British Architects (by examination).
(*f*) The holder of a commission in the Royal Engineers.
(*g*) The holder of such other degree or qualification as the Council may determine in specific cases.

Syllabus of the Examination.

PART I. (*A*) COMPULSORY SUBJECTS.

1. ***Principles of Statics and Theory of Structures.***—Forces acting on a rigid body; composition and resolution of forces; couples; moments of forces; conditions of equilibrium, with application to loaded structures. Graphical and analytical treatment of the foregoing. Centre of gravity; specific gravity.

Graphic and analytic methods for the calculation of bending moments, shearing forces, and the stresses in individual members of framed structures loaded at the joints; reciprocal diagrams; incomplete frames and redundant members; buckling of struts; effect of different end fastenings on their resistance; combined stresses; section modulus; methods of dealing with statically indeterminate problems, as beams supported at three points, etc.; travelling loads; rigid and hinged arches; stresses due to weight of structures; theory of earth pressure and of foundations; stability of masonry and brickwork structures.

2. Strength and Elasticity of Materials.—Physical properties and elastic constants of cast iron, wrought iron, steel, timber, stone, concrete, cement, and other materials; relation of stress and strain; limit of elasticity; yield-point; Young's modulus; coefficient of rigidity; extension and lateral contraction; resistance within the elastic limit in tension, compression, shear, and torsion; strength and deflection in simple cases of bending; beams of uniform resistance; reinforced concrete beams.

Ultimate strength with different modes of loading; plasticity and permanent set; working stress; phenomena in an ordinary tensile test; stress-strain diagrams; suddenly applied and impulsive loads; resilience; fatigue of metals; effects of hardening, tempering, and annealing.

Forms and arrangements of testing machines for tension, compression, torsion, and bending tests; instruments for measuring extension, compression, and twist; forms of test-pieces and arrangements for holding them; methods of ordinary commercial testing; percentage of elongation and contraction of area; test conditions in specifications for the principal materials of construction.

PART I. (*B*) SELECTIVE SUBJECTS.

Two of the following subjects must be taken in addition to the compulsory subjects :—

3. Chemistry.—Constitution of matter; chemical elements; Dalton's atomic theory; Newland's law of octaves; Mendeleeff's law of periodicity; modes of chemical action; atomicity; analysis and synthesis; composition of materials employed in structural engineering.

4. Physics. (*Note:* A candidate taking this subject must be prepared to answer questions in three of the five sections.)

Sound.—Nature of sound; pitch, intensity, and timbre; transmitting media; velocity of sound; sound waves; vibrating strings, plates, and membranes; resonance; interference; reflection and absorption of sound.

Light.—Theories of Light; transmitting medium; velocity of light; solar spectrum; laws of reflection; photometry; candle-power; candle-feet; absorption of light; colour; polarised light; action of lenses; telescope and microscope.

Heat.—Sensible and latent heat; thermometers; pyrometers; effect of change of temperature in solids, liquids, and gases; transfer of heat; radiation; conduction and convection; relative conductivity; thermal units; Joule's equivalent; thermal capacity; specific heat; combustion.

Magnetism.—Magnets; magnetic phenomena; magnetic field; polarity; the mariner's compass; magnetic meridian; deviation and declination of the compass; inclination or dip; induction; galvanometers.

Electricity.—Static and voltaic electricity; induction; conductors; electro-negative and electro-positive elements; electrolysis; lightning; system of electrical transmission; electrical units; measurement of electrical work; Ohm's law; principles of arc and incandescent lighting.

5. Hydraulics.— Pressure on surfaces; centre of pressure; strength and stability of structures supporting water pressure; laws of fluid friction; impact of water on surfaces; storage of water and construction of reservoirs.

6. Geology. — Classification of rocks; succession of strata in aqueous formations; explanation of geological terms; glacial drift; conditions of deposition in fresh and sea water; denudation; disintegration and chemical decomposition of rocks; method of dealing with bad ground for engineering works.

7. Geodesy. — The theory, structure, and adjustment of the principal surveying and levelling instruments, and the principles of their employment under various conditions; land surveying; contouring; levelling and use of theodolite.

PART II. TECHNICAL.

Subject 8 must be taken by all candidates, and at least one other subject.

8. Structural Engineering (Generally).—Materials of construction; loads—dead loads (distributed and concentrated), live loads (rolling and suddenly applied); bending moments; resistance moments; stresses and strains; shear stresses; deflection; secondary stresses; fatigue of metals; safety factors; wind pressures; standard sections of rolled steel; properties of sections; girders—rolled sections (simple and compound), plate web and lattice web, trussed frame; pillars, columns, stanchions, piers and struts generally; eccentric loading; fixity of ends; roofs—symmetrical and unsymmetrical trusses; connection of parts; bridges—girder, suspension, cantilever; arches—elastic rib, rigid and braced, two and three pivoted; methods of erection; testing and inspecting materials of construction; effect of workshop processes on steel; mass retaining walls and their stability against water pressure and earth pressure; pressures in silos, bins, and hoppers.

9. ***Reinforced Concrete Construction.***—General principles; advantages and disadvantages of reinforced concrete; materials of construction and their testing; nature and properties of materials for concrete; mixing concrete by hand and machine; effect of frost and precautions to obviate damage; laying concrete; testing actual concrete used; testing completed structures; failures and causes; comparison of cost with other methods of construction; fire-resisting properties; causes affecting expansion and contraction; surface finish, durability and maintenance; form work (centering, shuttering, strutting, moulds, etc.), precautions in fixing, order and periods of removal.

Routine of designing; arrangement of roof and floor slabs, cross beams, main beams, and pillars; loads on floors; calculation of reinforcement for various parts; loads on foundations; rough estimates of cost; rules and regulations.

10. ***Steel Frame Construction.***—Order of procedure in designing; external forces, wind, snow, etc.; arrangement of roofs; loads on floors; arrangements of main and cross girders and stanchions; caps and base plates; grillages; junctions; erection; brick and stone panels and casings; protection against fire; painting; rough estimates of cost; rules and regulations.

Candidates desirous of being examined in Masonry, Bridgework, or any other branch of Structural Engineering not specified above may be so examined subject to the approval of the Examination Board and upon notifying the Secretary at least six weeks beforehand.

THE ANNUAL GENERAL MEETING.

THE Annual General Meeting of the Institute was held at Denison House, Vauxhall Bridge Road, S.W., with the outgoing President, Mr. E. P. Wells, J.P., in the chair. Unfortunately, there was only a very small attendance, and the discussion was thus kept within merely formal limits. We present a summary below of such discussion as there was, at the same time mentioning that the new President, Professor Henry Adams, M.Inst.C.E., was installed in the chair and took charge of the conclusion of the meeting.

A special feature of the proceedings was the presentation of a medal to Mr. S. Bylander for his excellent paper, entitled "Steel Frame Buildings in London," which token he certainly merited.

DISCUSSION.

THE PRESIDENT, in moving the adoption of the Report and Accounts, referred specially to the time devoted to the new Regulations upon Reinforced Concrete, which had occupied many hours. He believed the Regulations would become law in a very short time, and most of those interested in reinforced concrete, he was afraid, would find them very stringent indeed. There was a lot of other work to be carried on in the next year, which had had to be deferred owing to the amount of time that had been spent on these Regulations.

SIR HENRY TANNER, Kt., I.S.O., seconded the motion. The Council were to be congratulated on the increased amount of work they had done during the past year, and the number of papers which had been read must add much to the usefulness of the Institute.

As to the financial situation, they had had some undue expenditure during the past year, but he was very glad to hear the President say that he thought, proceeding as they were, they should be in a better condition at the end of the next financial year.

MR. EDWIN O. SACHS, F.R.S.Ed., did not wish to occupy their time on the annual report at a short formal meeting of that description, with a small quorum present. He congratulated the Institute on the excellent work which it had done in connection with the London County Council Reinforced Concrete Regulations. The work had been most studiously and carefully undertaken, and they hoped that there would be a successful issue to what had been done in that direction. It was a matter for congratulation that the papers had been more numerous and that some of them had been so interesting.

The only point of criticism he wished to raise at the moment was in regard to what he might term the "Reorganisation" scheme. It struck him—and he spoke on behalf of a large number of members not resident in London—that the Council had been trying to go too fast, and that much trouble and friction could have been avoided by going slowly. There had been not only an admitted attempt to materially change the policy of the Institute, but that change had unfortunately been accompanied by, what he would term by courtesy, some most unfortunate errors or misunderstandings, and considerable muddling, which had not conduced to the prestige of the Institute.

They all hoped, he was sure—and he thus emphasised it on behalf of a large number of country members—that the coming year would find some way out of these troubles, that compromise might be found to be the suitable way out, and that Professor Adams in his year of office might not have a troublous, but a pleasant time to look back upon when he ended the very difficult work of presiding over the meetings of the Concrete Institute.

Mr. H. D. Searles-Wood, F.R.I.B.A., echoed Mr. Sachs' sentiment, and hoped there would be a little careful consideration, that they might resume their harmonious meetings again.

The Chairman put the Resolution to the meeting, and it was unanimously adopted.

The President then presented the bronze medal of the Institute to Mr. S. Bylander for the best paper that was read in the Session 1912-13. It was a most excellent paper.

Mr. Bylander, in acknowledging the compliment, said he considered that the Concrete Institute was doing real good work for the engineering profession at large and reinforced concrete and steel-work in particular.

The President said the last important business was for him to vacate the chair, after being in it for two years, and to instal Professor Henry Adams as the President for the ensuing two years. He desired to thank all the members for the extreme kindness they had shown him. In asking Professor Adams to take the chair, he hoped at the end of his term he would be able to announce an increase in the membership, and he trusted that the Institute would be more looked up to than it was at the present time.

Professor Adams, M.Inst.C.E., then took the chair. He said that during his term of office he should use his best endeavours to serve them faithfully and impartially so long as he occupied the chair. Whatever his personal opinions might be upon any matter that came before the Institute, he should feel in duty bound, not only loyally to support, but to give effect, to the best of his ability, to the wishes of the majority; and he hoped that in a very short time they should be able to find some method by which the members all over the world would be able to have a voice in the management of the Institute.

Mr. H. D. Searles-Wood, F.R.I.B.A., proposed a vote of thanks to the outgoing President.

Mr. E. Morgan Yeatman, M.A., in seconding the vote of thanks, said he hoped that in the position of past-President Mr. Wells would continue to give the Institute his assistance on the Council.

The Resolution was carried by acclamation.

Mr. Wells, in returning thanks, remarked that his best endeavours would be at the service of the Institute.

Corner of Market and Kearny Streets, San Francisco.
PANAMA-PACIFIC EXPOSITION.

PANAMA - PACIFIC EXPOSITION.

REDUCING THE FIRE HAZARD.

By JOHN GEO. LEIGH.

In the following article it is shown how concrete and reinforced concrete have entered into the scheme of building for this Exhibition, primarily with a view to protection from fire.—ED.

VIEING with the marvellous resources of the country tributary to San Francisco are the advantages which have been conferred upon the city by geographical position and a splendid harbour. The commerce of the port has grown year by year, ever quickened by the opening of the Pacific, the discoveries in Alaska, the awakening of China and Japan, the acquisition by the United States of its island possessions, and, last but not least, by the certain completion of the Panama Canal.

To celebrate this great event, and commemorate, unofficially, the city's resurrection from the overwhelming catastrophes of 1906, San Francisco is preparing a magnificent pageant, by which, coupled with a pledge to receive them with true Californian hospitality,

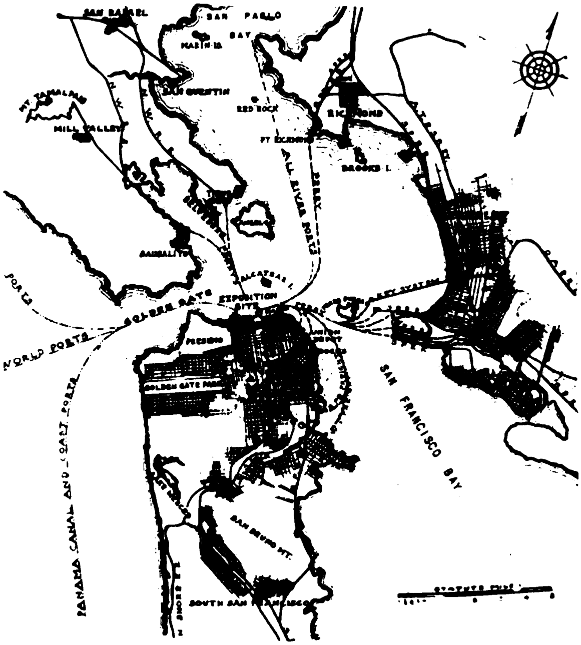
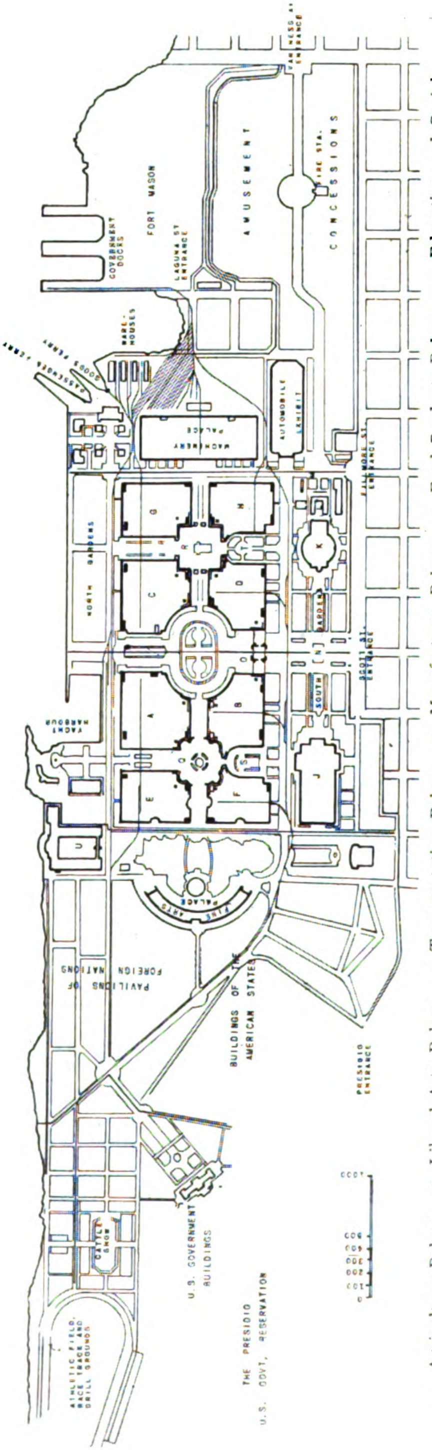


Fig. 1. San Francisco and its Environs.
PANAMA-PACIFIC EXPOSITION.



A. Agriculture Palace. B. Liberal Arts Palace. C. Transportation Palace. D. Manufactures Palace. E. Food Products Palace. F. Education and Social Economy Palace. G. Mines and Metallurgy Palace. H. Varied Industries Palace. J. Horticulture Palace. K. Festival Hall. L. Administration Building. M. Main Fire Engine Station. N. Court of the Universe. O. Main Tower. Q. Court of the Four Seasons. R. Court of Abundance. S. Court of Palms. T. Court of Flowers. U. California State Buildings.

The approximate situation of the Concrete Fire Walls in the Main Courts is indicated by an asterisk * and that of the Transformer Vaults by black rectangles.

Fig. 2. General Plan of the Buildings and Grounds. Panama-Pacific Exposition.

it hopes to attract ten millions of people gathered from all quarters of the world. Already visitors to San Francisco find it difficult to realise that eight years ago practically the entire city—excepting a residential district on the north-west and a fringe of houses in another corner—was little better than a mass of smouldering ruins. Hosts of friends rose up to succour it, giving its people hope and courage in the great, though seemingly impossible, work that lay before them. The result is a San Francisco even more beautiful and impressive than that of former days—a triumph, on the one hand, of honest wooden structures and, on the other, of steel-frame and reinforced concrete. Rivalling as a monument to human skill and industry even the Panama Canal and International Exposition, which, on the day it opens, will represent an aggregate expenditure of £10,000,000, will be the new-built city.

In view of the proximity of the latter to large lumber-producing centres and the necessarily temporary nature of exhibition structures, the Exposition authorities have endeavoured to eliminate so far as possible the general use of building materials such as steel, brick, stone and concrete. Very conspicuous, however, in their construction programme have loomed the questions of fire prevention and protection, and it is with this side of their activities that the present article will primarily deal. From the general plan of the grounds and buildings (*Fig.* 2) it will be seen that the main exhibition palaces are twelve in number. Of these eight are comprised in a central group, the walls of the various buildings being treated with colonnades and other architectural features serving as sides of the connecting courts and avenues. Here and there, also, are placed various arches, towers, etc. The four remaining buildings form separate units, the Palaces of Machinery and of Fine Arts flanking respectively the eastern and western extremities of the main group, while the Horticulture

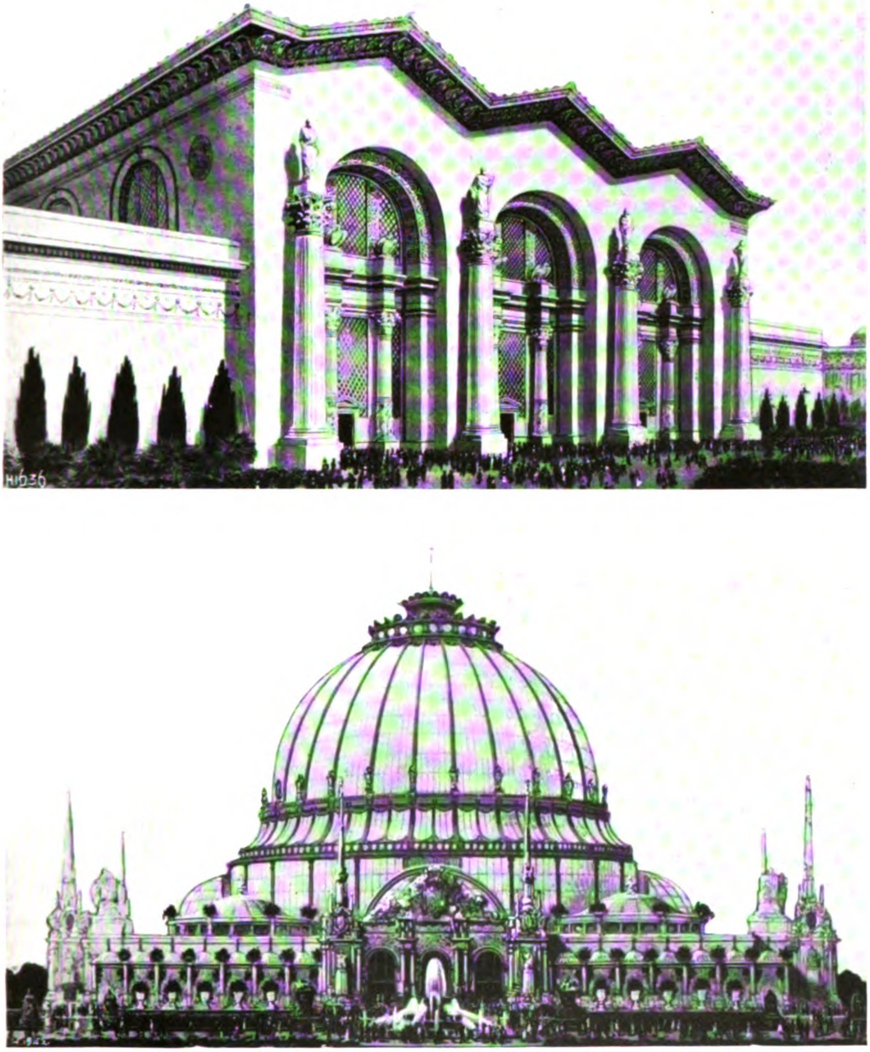


Fig. 3. (1) Palace of Machinery. (2) Palace of Horticulture.
Panama-Pacific Exposition.

Palace and Festival Hall are set in gardens to the south. In the centre of the south line of the main group, fronting the main entrance to the Exposition and on the north and south axis, is the Tower Gate (*Fig.* 5), a sculptured mass rising to a height of 435 ft.—leading from the Court of the Universe to the Court of Honour. That this grouping involves a great fire risk is sufficiently evident from the fact that—with the exception of the Palace of Fine Arts, the Main Entrance Tower, and the dome and dome substructure of the Palace of Horticulture—timber is exclusively employed in the frames, wall studding, and sheathing of all the buildings. To reduce this hazard the authorities have adopted several extraordinary measures and introduced not a few noteworthy innovations in exhibition building construction. Among the former may be mentioned a fine equipment of fire-fighting apparatus, such as motor-driven fire engines, hose wagons, and hook and

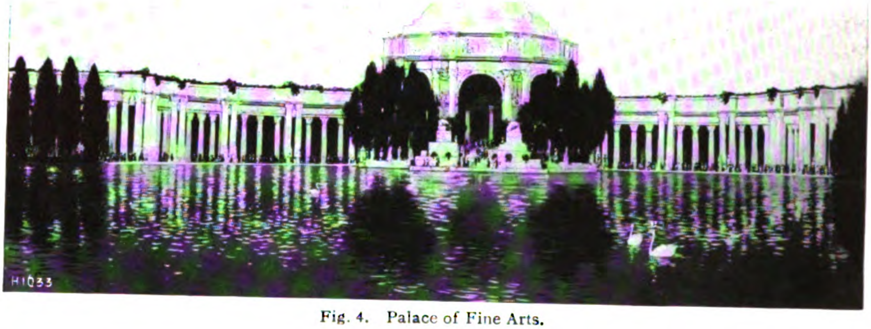


Fig. 4. Palace of Fine Arts.

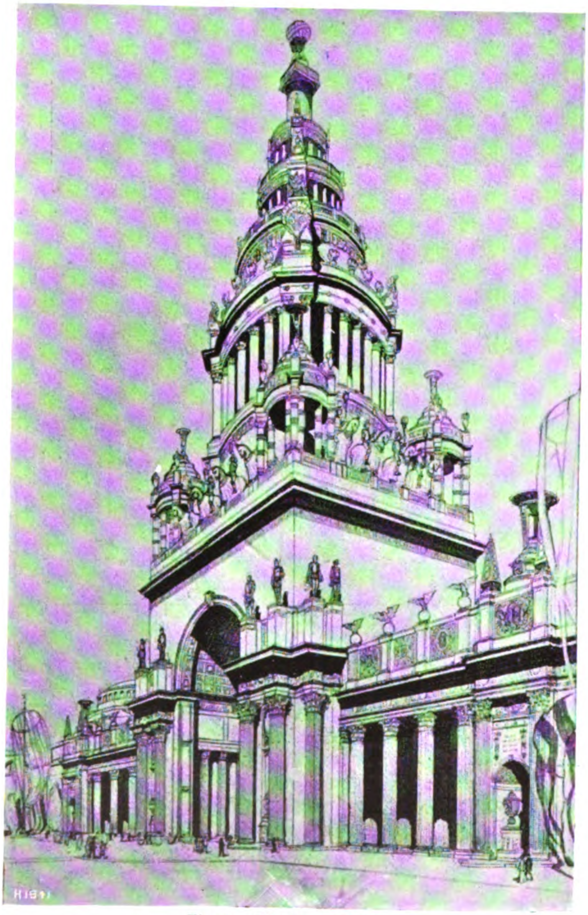


Fig. 5. The Tower Gate.
PANAMA-PACIFIC EXPOSITION.

ladder trucks; high-pressure and secondary water systems throughout the grounds and buildings, with static pressures of respectively 300 lb. and 50 lb. to 60 lb. per sq. inch; automatic sprinklers throughout the interior of the buildings, and open corner sprinklers between buildings and on buildings facing each other; an automatic fire alarm system, and such protective devices as wheel and hand chemical extinguishers. Especially valuable, however, in the event of danger should be the concrete "fire walls" extending from the ground to the tops of the various parapets and—with the object of preventing the spread of fire—subdividing the main group of buildings into separate units.

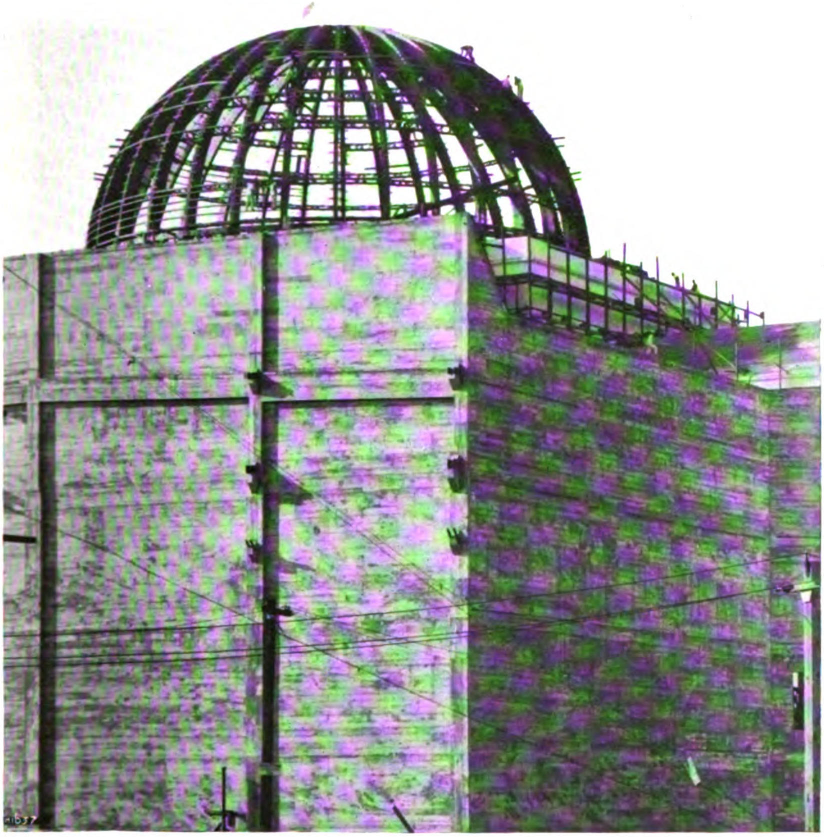
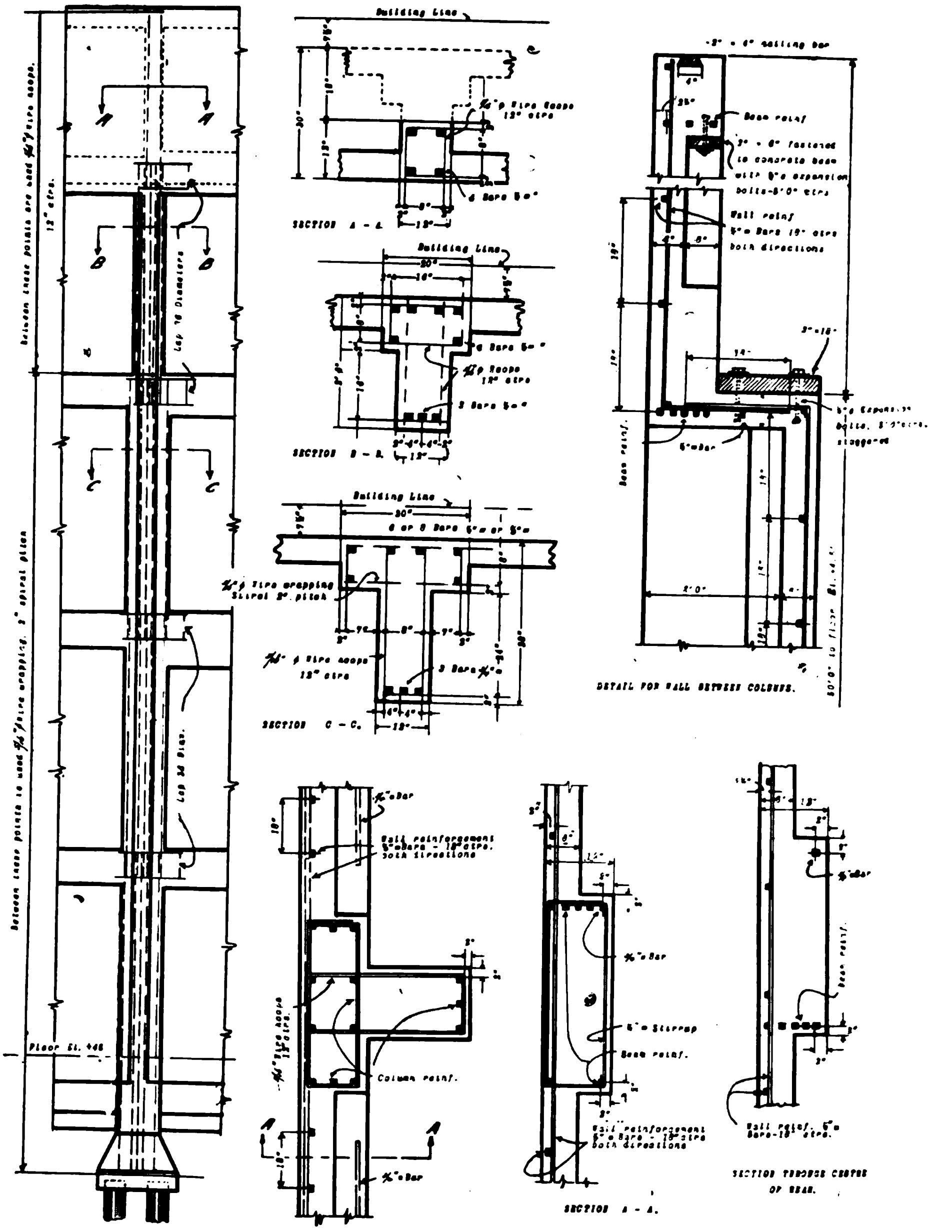


Fig. 6. Concrete "Fire Wall"—Palace of Education.
PANAMA-PACIFIC EXPOSITION.

As indicated in *Fig.* 2, these walls are erected at the ends of structures connecting two buildings across an intervening court. They are composed of a 6-in. curtain wall reinforced by ½ in. sq. steel bars, 18 in. centres in both directions, and are supported by concrete spandrel beams, which, in turn, are supported by reinforced concrete columns, resting upon concrete caps supported on driven wooden piles. These "fire walls" are used in place of the regular con-


Building Line
SECTION A – A.
Section B – B.
SECTION C – C.
6 or 8 Bars ⅝" ⌀ or ¾" ⌀
⅜" ⌀ Wire wrapping Spiral 3" pitch
⅜" ⌀ Wire hoops 12" ctrs
3 Bars ⅞" ⌀
¼" ⌀ Wire Hoops 12" ctrs
4 Bars ¾" ⌀
Beam reinf.
2" × 6" fastened to concrete beam with ½" ⌀ expansion bolts–3'0" ctrs
Wall reinf. ½" ⌀ Bars 18" ctrs both directions
½" ⌀ Expansion bolts, 3'0" ctrs staggered
¾" ⌀ Bar
50'0" to Floor El.
Between these points are used ⅜" ⌀ wire hoops. 12" ctrs.
Between these points is used ⅜" ⌀ wire wrapping, 3" spiral pitch
Lap 70 Diameters
Lap 36 Diam.
Floor El. 446
Wall reinforcement ½" ⌀ Bars – 18" ctrs. both directions
Column reinf.
½" ⌀ Stirrup
Wall reinf. ½" ⌀ Bars–18" ctrs.

DETAIL FOR WALL BETWEEN COLUMNS.

SECTION A – A.

SECTION THROUGH CENTRE OF BEAM.

ELEVATION OF TYPICAL COLUMN SHOWING REINFORCEMENT.
Scale ins. = 1 ft.

PLAN & SECTION SHOWING DETAIL OF TYPICAL WALL REINFORCEMENT.

Fig. 7. Typical Details of "Fire Wall" Construction.
PANAMA-PACIFIC EXPOSITION.

struction of timber columns, by bykritt sheathing (grooved wood sheathing lath) and plaster. In *Fig.* 7 will be found some typical details of this "fire wall" construction, *Figs.* 8 and 9 being photographs of walls taken during the progress of the work.

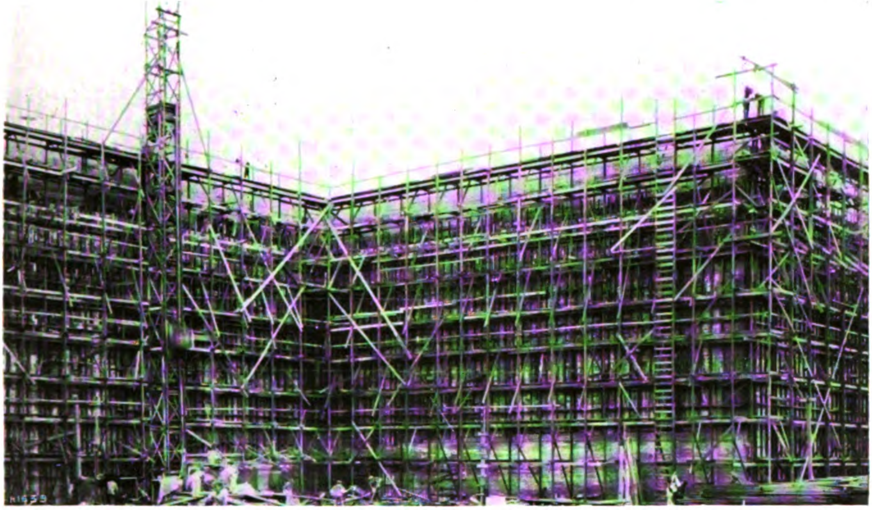


Fig. 8. Concrete "Fire Wall," view showing form work.
PANAMA-PACIFIC EXPOSITION.

A careful study of other types of fire-resisting walls, such as brick self-supporting walls and steel columns and beams with an 8-in. brick or 6-in. concrete curtain wall, resulted in the selection of the above-mentioned type as the most economical in respect both of cost and speed of erection. In this inquiry a concrete wall 6 in. thick was considered equivalent for fire-resisting purposes to an 8 in. brick wall. The concrete which has been used is a mixture of cement, sand, gravel, and blue trap rock, in the proportions of one part cement to six of aggregate, the various parts of the latter being determined from time to time by laboratory tests. The average cost of this wall, including curtain wall, beams and columns, and reinforcing steel and beams, has been approximately 2s. 1d. per sq. foot of surface.

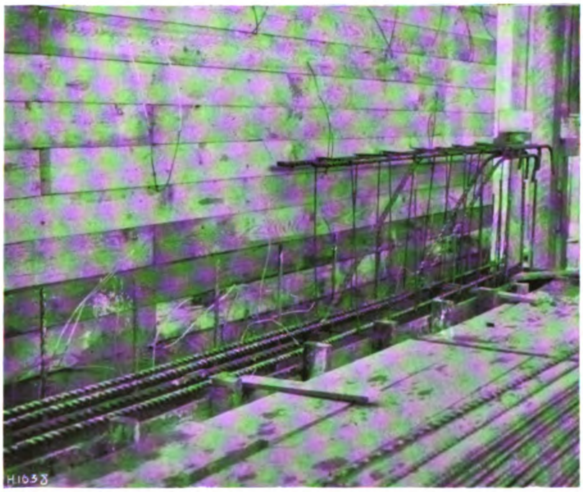


Fig. 9. Concrete "Fire Wall," view showing arrangement of reinforcing rods in concrete beam.
PANAMA-PACIFIC EXPOSITION.

Other fire-resisting materials are being used in the construction of the Palace of Fine Arts (*Fig.* 4). Though isolated from the main group of buildings, and therefore less liable to fire risks, this edifice has called for special protection, because of the anticipated valuable exhibits for which it has been prepared. The Fine Arts Palace, consequently, will be constructed with a steel frame, with walls and roof of cement plaster applied to an expanded metal lath, known as "Trussit," manufactured by the General Fireproofing Company, of New York and 34 and 36, Gresham Street, London. The roof slab is approximately 3 in. thick, while the vertical walls have a thickness of 2½ in. The trussit, 24 gauge and 1 in. thick, is laid horizontally, and fastened to the steel frame (see *Fig.* 10) by means of special wire clips placed 5 in. on centres. The corrugations of the lath interlock at the ends, and are fastened with 16-gauge tie wires at intervals of 12 in.

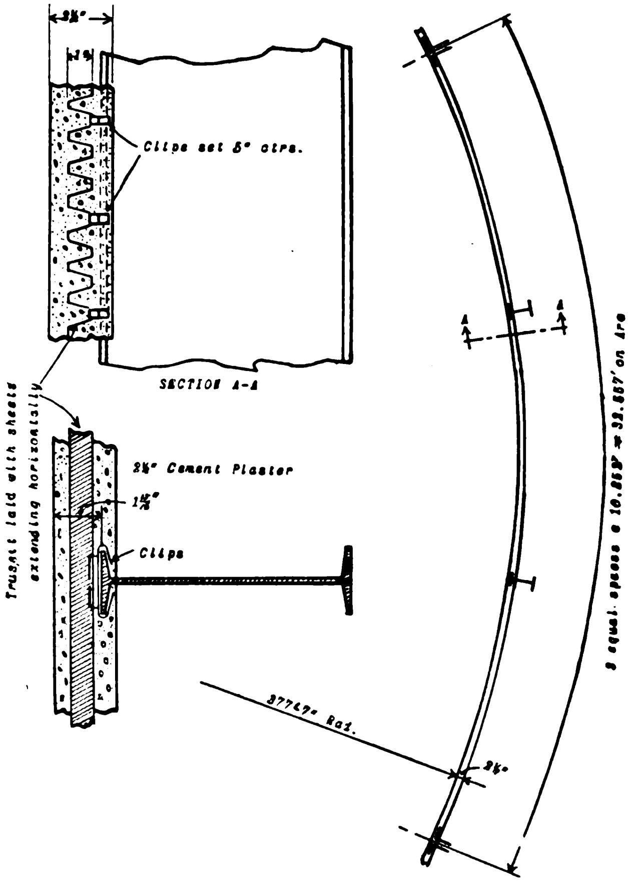

2¼"
1⅛"
Clips set 5" ctrs.
SECTION A-A
Trussit laid with sheets extending horizontally
2¼" Cement Plaster
1⅛"
Clips
A
A
37747" Rad.
2¼"
3 equal spaces @ 10.859' = 32.587' on Arc

Fig. 10. Trussit Wall and Roof Reinforcement.
PANAMA-PACIFIC EXPOSITION.

The cement plaster used consists of one part Portland cement, three parts sand, and a small amount of hair, well tempered with lime mortar to set up hard and firm. The metal lath is supported temporarily on the inside face by studding, and the first coat of plaster is applied to the fabric on the outside and floated to an even surface with a depth of at least ⅜ in. over the extreme projections of the metal. After the first coat has set, the temporary studding is removed and the opposite side of the metal plastered as noted for the first coat, allowing for a total thickness of 2½ in., including the final plaster coat. This gives, in effect, a reinforced wall of minimum thickness. Concrete, it may be explained, was not used, for the simple reason that the necessarily thicker wall would have been more costly. The final coat is of hard wall plaster, coloured and stippled in imitation of travertine marble—the characteristic finish surface on all the Exposition palaces.

A wall construction similar to that just described will be used for the Main Tower Gate, except that the plaster wall will be supported by a wooden instead of a steel frame. In the design of this tower the type of construction adopted is a steel structure which supports the timber framework of the floors and walls. This, although certainly not fireproof, may be termed fire-resisting, and an approach to what is commonly known as "mill construction." The general frame of the walls is built up of 6-in. by 6-in. posts, about 8ft. on centres, with horizontal girts 10 ft. centres, all with flush outside surfaces. To this framework is fastened the metal lath, the ribs of which run horizontally, and this in turn is attached to the supports with 1½-in. galvanised iron staples, 9 gauge, 6 in. centres. The cement plaster is then applied as in the case of the Palace of Fine Arts.

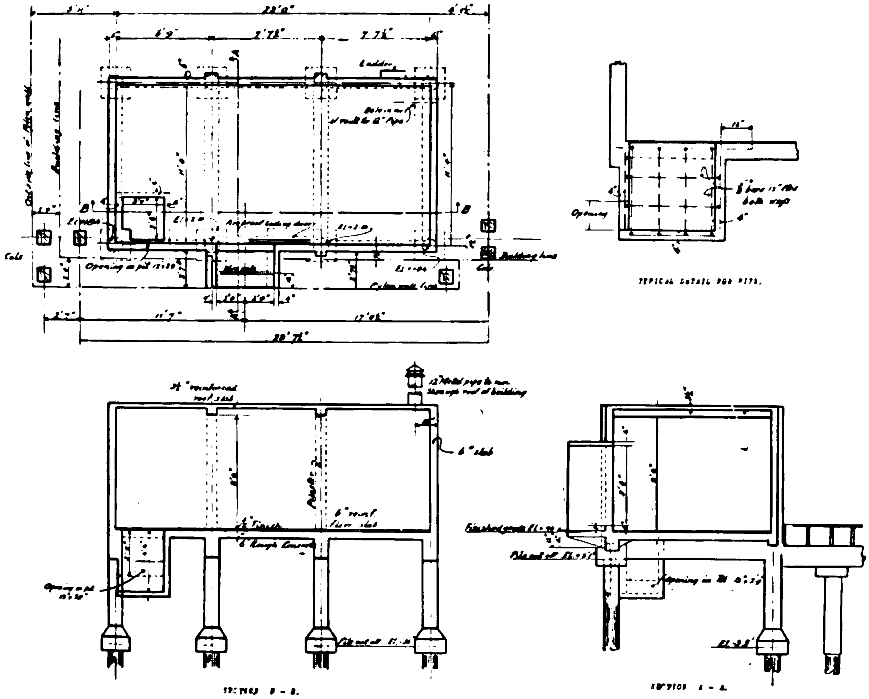


Fig. 11. Typical Details of Transformer Vault Construction.
PANAMA-PACIFIC EXPOSITION.

Alternate current will be distributed in conduits throughout the Exposition grounds at 4,000 volts, and will be stepped down, where required, to the adopted secondary voltages. For this purpose suitable fireproof transformer vaults, built of reinforced concrete throughout, are placed in all the main buildings in situations indicated in the general plan, *Fig.* 2. These vaults, of which typical details are shown in *Fig.* 11, are approximately 10 ft. by 10 ft. by 10 ft. high, having walls reinforced with ⅜-in. sq. bars, 18 in. on centres horizontally and vertically. In *Fig.* 12 are illustrated two of the vaults in course of construction.

Another use of concrete likely to be of interest to many readers may be noted in connection with the footing grillages. These generally, whether for pile or spread footings on earth, are of timber; elsewhere, however, and conspicuously in the case of the Main Tower Gate, they are of concrete, reinforced with steel bars. The footings of this structure are twelve in number and of three different sizes, the largest—14 ft. 6 in. by 17 ft. and 4 ft. 9 in. thick—capping a cluster of 42 wooden piles and supporting the cast-steel base of a tower leg. For a building of such magnitude it was deemed advisable to abandon the use of timber for grillage and adopt either a steel I beam grillage embedded in concrete or a reinforced concrete slab, and preference was given to the latter design because of its marked economy.

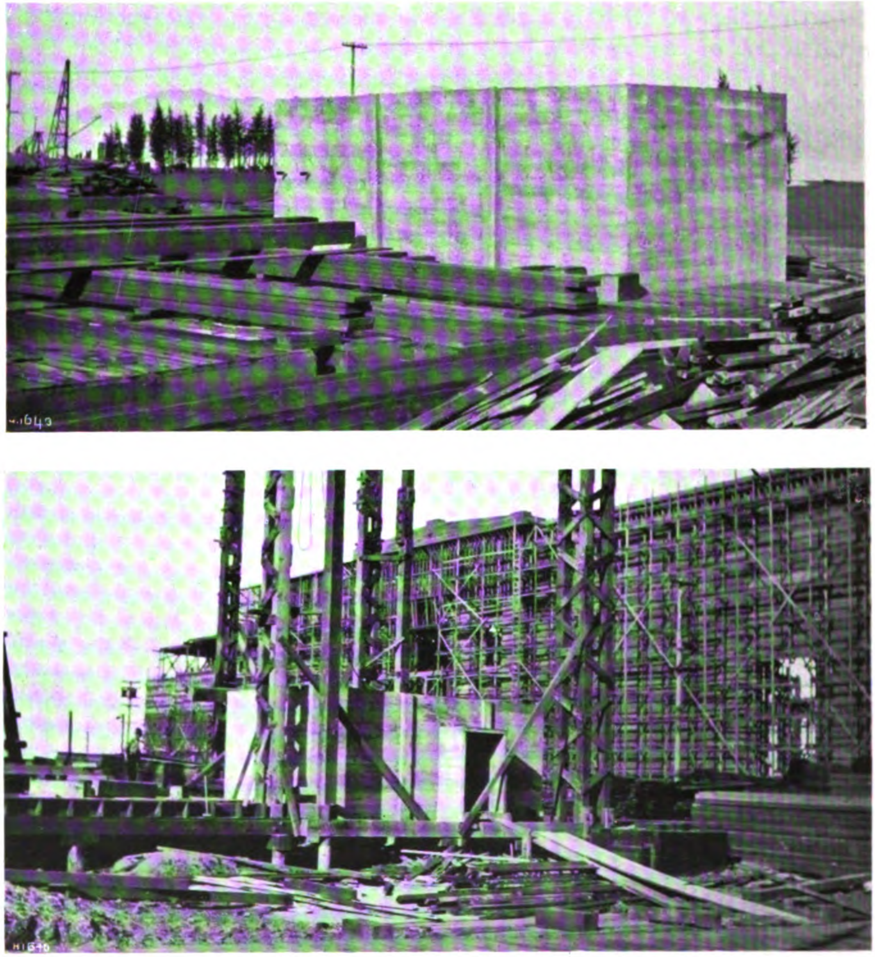


Fig. 12. Concrete Transformer Vaults.
(1) In the Mines and Metallurgy Palace; and (2) In the Varied Industries Palace.
PANAMA-PACIFIC EXPOSITION.

Taking the Exposition as a whole, there can be no question that the fire-resisting qualities of concrete, combined with its strength and cheapness when compared with steel and brick construction, have appealed with great force to the authorities, and that in many minor directions also—*e.g.*, as foundation for the wooden manholes for both the sewer and water systems, as backing for the electric conduits, as manholes for the high pressure water system, and as steps and caps for balustrades—the material has been warmly welcomed.

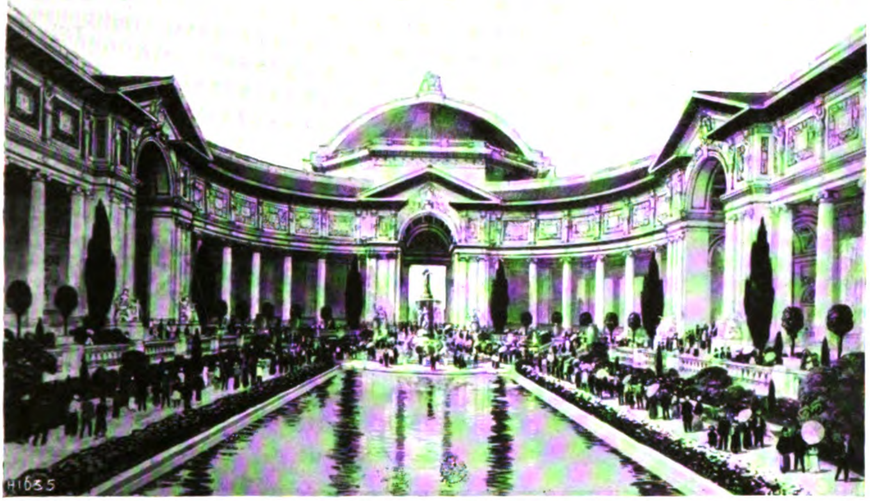


Fig. 13. Court of Palms.
PANAMA-PACIFIC EXPOSITION.

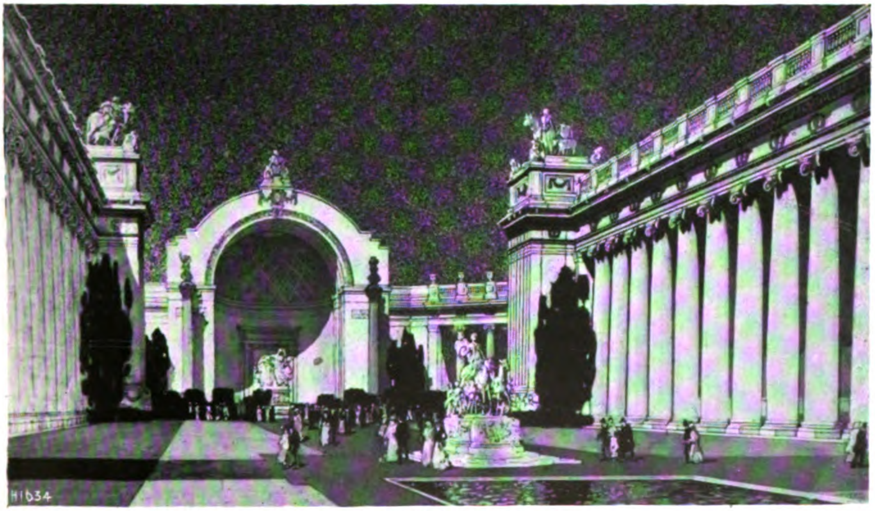


Fig. 14. Court of the Four Seasons.
PANAMA-PACIFIC EXPOSITION.

Supplementary to the Festival Hall within the Exposition grounds proper, and for the purpose of accommodating the various conventions, musical gatherings and other functions of kindred character which are being arranged for the coming year, the Exposition Company is building at the junction of Van Ness Avenue and Market Street—in what is fitly described as the civic centre of San Francisco—a fireproof permanent Auditorium. This building, intended as a gift to the municipality and to form part of the new city planning scheme, covers an area of 113,438 sq. ft., and will have seating capacity for 10,000 persons. The materials which are being used in construction are steel, stone, brick, terra cotta and concrete. The foundations and footings are of mass concrete, one part cement, three parts sand, and four parts broken rock; while all retaining and partition walls and corresponding foundations are of concrete of the proportions 1 :2 :4, the whole being reinforced where required with deformed bars. The superstructure is a steel frame, fireproofed with concrete of a similar mix, the columns and steel beams, which are reinforced with Clinton welded fabric, 5 in. by 9 in. mesh, 12 and 13 wire, being so covered that there is a minimum of 2 in. of fire-proofing on all parts. The floors throughout are reinforced concrete slabs, spans up to 6 ft. 8 in. being 3½ in. thick, reinforced with Clinton welded fabric, 3 in. by 16 in. mesh, 3 and 8 wire, giving a net area of ·187 per foot of width. Slabs from 6 ft. 8 in. to 8 ft. 8 in. are 4 in. thick, and spans greater than 8 ft. 8 in. are 4 in. thick, both being reinforced with 2½ in. by 16 in. mesh, 3 and 8 wire. The fabric in all cases is continuous over the tops of the floor beams. The basement and main floors under the Auditorium, respectively 5¼ in. and 7 in. thick, are laid directly upon the ground. The balcony construction, also of concrete, is banked up with 6-in. walls and slabs, reinforced with deformed bars.

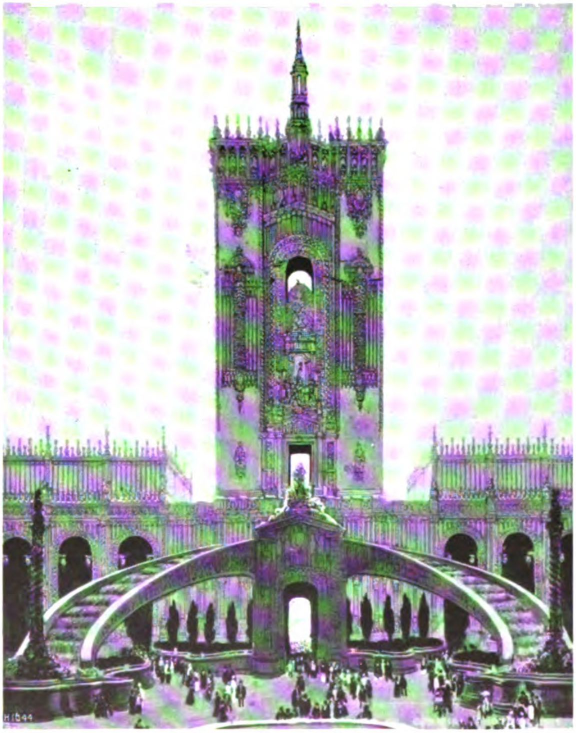


Fig. 15. Court of Abundance.
PANAMA-PACIFIC EXPOSITION.

The grounds dedicated to the purposes of the Exposition comprise 635 acres, divided into three sections and having about two miles of water front. In the centre are grouped in a rectangle, 2,900 ft. by 1,437 ft., eight of the great exhibition palaces, with a central Court of Honour, 500 ft. by 900 ft., and, west and east of this, wide avenues forming subsidiary courts. At one end of the group is the Fine Arts Palace, a long curved building, with an area, including colonnade and rotunda, of 204,325 sq. ft., while at the other extremity is the Machinery Palace. The latter—367 ft. by 967 ft. and 103 ft. in height—is probably the largest timber building ever erected. The foundations required 1,600 piles, the carrying capacity being taken at 20 tons per pile, and the timber in the building itself amounts to about 7,600,000 ft., board measure. Flanking this is a building, 250 ft. by 800 ft., intended for automobile and motor-car exhibits; and westward, on either side of the main entrance, are the Palace of Horticulture—constructed almost entirely of glass, 630 ft. by 300 ft., with a dome of 152 ft. diameter, rising to a height of 188 ft.—and the Festival Hall, with an area of 57,400 sq. ft. and seating capacity for about 3,000 persons. The main buildings have interior arched aisles, with a dome of 100 ft. at the centre, their height, as a general rule, being 65 ft. to the cornice, 96 ft. to the ridge and 160 ft. to the top of the dome.

East of the buildings mentioned above are 65 acres devoted to amusements, usually known as "side shows," the concessions for which—fewer than 100 out of a total of more than 6,000 applications—have, it is stated, been granted with "the most rigid selectiveness," having satisfied "a high standard of propriety, good taste and educational value, as well as effective fun-making and entertainment." To the west are 65 acres assigned for the buildings of foreign Governments, 45 acres for those of the States of the Union, 12 acres for the exhibits of the Federal Government, and large areas for the live stock exhibition buildings, racecourse, aviation field, drill grounds, etc. The two-story building to be occupied by the exhibits of the State of California will be in what is called the "old mission" style, reminiscent of the Spanish occupation, and will cover approximately 3,550 ft. by 675 ft.

A quite unusual system has been adopted for the exterior lighting of the buildings, the rows of incandescent lamps characteristic of the majority of recent exhibitions being replaced by arc lamps and concealed searchlights so screened and directed as to flood with light the entire fronts. It is intended to open the Exposition on February 20th, when many of us hope to find the United Kingdom more worthily represented than appears probable at the present moment, and to continue it until December 4th—an exceptional period due to the favourable climatic conditions ordinarily prevalent in the City of the Golden Gate.

Warm acknowledgments are due from CONCRETE AND CONSTRUCTIONAL ENGINEERING and the writer personally to the Exposition authorities—and particularly to Mr. Harris D. H. Connick and Mr. A. H. Markwart, respectively the Director and Assistant Director of Works—for much invaluable information and for placing at their disposal a large and interesting selection of drawings, etc.; and also to the H. S. Crocker Co., the official photographers, for a variety of excellent photographs of San Francisco and its environs and of the Exposition itself.

PROBLEMS IN THE THEORY OF CONSTRUCTION.

SLAB FORMULÆ FOR REINFORCED CONCRETE DESIGN.

By **EWART S. ANDREWS**, B.Sc.Eng.

The question of Slab Formulæ for Reinforced Concrete design is one which claims considerable attention, and the article here published will doubtless be of interest to those studying this important question. Following upon this article is also a short article on a Bending Moment Problem, also by Mr. Andrews.—ED.

VERY many mathematical investigations have been made from time to time by elasticians to determine the strength of slabs or plates supported along all four edges; with the growth of reinforced concrete construction these investigations have received renewed attention. In the present article we propose to show how some such formulæ can be derived in a simple manner and to compare such formulæ with others which are in common use. The formula which is in most common use in this country is known as the Grashof-Rankine formula, and is the result of mathematical reasoning which is very difficult to follow, and experiments have not, we think, proved this formula to be much superior to others.

Prof. Bach's theory is very much simpler to follow, and we will consider this first, restricting our consideration to uniformly distributed loads. This theory is, however, not in very common use because, in accordance with the usual manner in which its results are expressed, the reinforcement should be placed diagonally. We shall first show how this theory can be adapted to the ordinary case of reinforcement parallel to the sides of the slab.

The fundamental assumption in Bach's theory is that the reaction pressure of the slab along the four sides is constant. It is generally thought that this assumption is not quite correct and that the pressure is rather greater towards the centre of the sides. We will, therefore, deduce three sets of slab formulæ based upon the following assumptions:—

(1). Pressure upon supports uniform.
(2). Pressure variation upon sides in accordance with a parabola.
(3). Pressure variation upon sides in accordance with a triangle.

CASE I. UNIFORM PRESSURE.

This is Bach's Theory; it is usually expressed as follows. Assuming that the diagonal sections are the weakest, consider the bending moment about the line AC, *Fig.* 1.

Let p be the pressure per unit length along the supports and let W be the total uniformly distributed load and w its intensity per unit area.

Then

$$p = \frac{W}{2(l+b)} \qquad (1)$$

The supporting forces or reactions may be taken as a force equal to pb acting at Y and one equal to pl acting at X; the load on the $\triangle\ ABC = \frac{W}{2}$ and acts at the centroid G of the $\triangle$.

The perpendicular distance of X and Y from AC are each $\frac{a}{2}$ and the perpendicular distance of G from AC is $\frac{a}{3}$.

$\therefore$ Taking moments about AC we have:

$$\text{Bending moment} = B = \frac{pb \times c}{2} + \frac{pl \times c}{2} - \frac{W}{2} \cdot \frac{a}{3}$$

$$= \frac{a}{2}\left\{p(l+b) - \frac{W}{3}\right\}$$

$$= \frac{a}{2}\left\{\frac{W}{2} - \frac{W}{3}\right\}$$

$$= \frac{Wa}{12} \qquad (2)$$

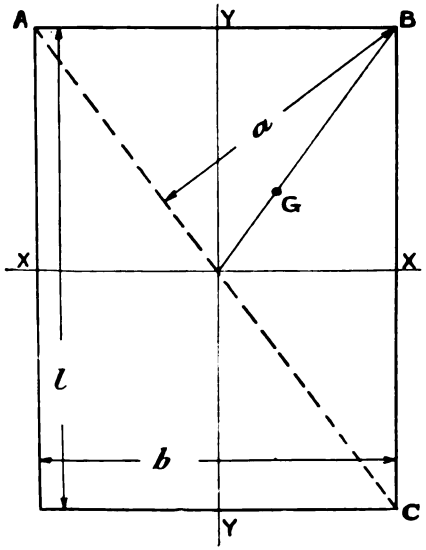


FIG. 1.

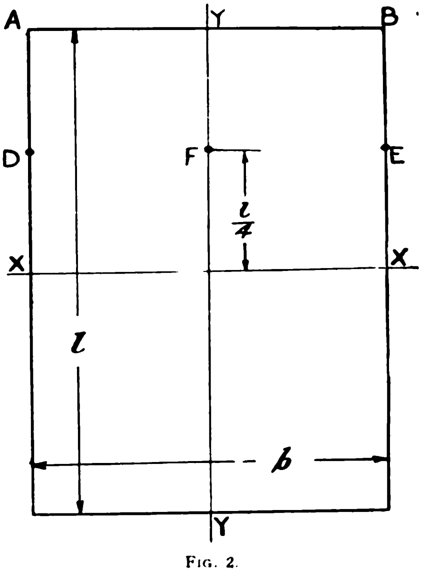


FIG. 2.

But $\qquad a \times AC = 2 \text{ area of } \triangle\ ABC = lb.$

$$\therefore\ a = \frac{lb}{AC},$$

$$\therefore\ B = \frac{W.lb}{12AC}$$

$$= \frac{Wlb}{12\sqrt{l^2+b^2}} \qquad (3)$$

Now this has to be resisted by the section AC, and if d_s is the effective thickness or depth of the slab, we have

$$B=\mu\,.\,AC\,.\,d_s^2$$

where μ = resistance modulus.

μ depends upon the percentage reinforcement and the working stresses adopted. For the "economic reinforcement" of ·675 per cent. for $c=600$ and $t=16{,}000$, $\mu=95$; for other percentages and stresses its value may be taken from the curves which are given in the text-books upon reinforced concrete.

∴ In equation (3)

$$\begin{aligned}\mu\,.\,d_s^2&=\frac{Wlb}{12AC^2}\\&=\frac{Wlb}{12(l^2+b^2)}\\&=\frac{wl^2b^2}{12(l^2+b^2)}\\&=\frac{wb^2}{12\left\{1+\left(\frac{b}{l}\right)^2\right\}}\end{aligned}\qquad(4)$$

If we neglected the supports on the short sides we should have:

$$B=\frac{Wb}{8}$$

where B = Moment of Resistance of section YY

$$=\mu d_s^2\,.\,l$$

$$\therefore\ \mu d_s^2=\frac{Wb}{8l}=\frac{wb^2}{8}\qquad(5)$$

We could get result (4) from (5) by multiplying by $\frac{2}{3\left\{1+\left(\frac{b}{l}\right)^2\right\}}$, this quantity being called a *slab coefficient*, which has the following values:—

$\frac{l}{b}$	Diagonal slab coefficient.
1	·333
1·25	·407
1·5	·461
1·75	·502
2	·533

This is the most convenient way of expressing Bach's theory for diagonal reinforcement. In general, however, the reinforcement is placed parallel to the two sides of the slab instead of diagonally; we can therefore proceed as follows:—

Bach Theory applied to Reinforcement Parallel to Sides of Slab.

We can consider in a similar manner the strength of the section XX, *Fig.* 2.

The reactions on the sides will have reactions at the mid-points equal to $\frac{pl}{2}$ at D and E and pb at Y. The load acts at the point F.

Therefore, taking moments about the line XX we have:

$$B=2\cdot\frac{pl}{2}\cdot\frac{l}{4}+pb\cdot\frac{l}{2}-\frac{W}{2}\cdot\frac{l}{4}$$

$$=\frac{pl}{4}(2l+b)$$

$$=\frac{Wl(2b+l)}{8(l+b)}-\frac{Wl}{8}$$

$$=\frac{Wbl}{8(l+b)} \qquad (6)$$

Neglecting side support on long side, we should have:

$$B=\frac{Wl}{8}$$

∴ Slab coefficient for $XX=F_l=\frac{b}{l+b}=\frac{1}{\frac{l}{b}+1}$ (7)

Similarly, if we consider the strength of the section YY we should get:

Slab coefficient for $YY=F_b=\frac{l}{l+b}=\frac{1}{1+\frac{b}{l}}$ (8)

These results can be tabulated as follows:—

$\frac{l}{b}$	Slab coefficients	
	Short section XX	Long section YY
	F_l	F_b
1	·500	·500
1·25	·444	·556
1·5	·400	·600
1·75	·364	·636
2	·333	·667

CASE II. PRESSURE VARIATION ACCORDING TO PARABOLA.

We have previously pointed out that there is reason to believe that in rectangular slabs the supporting pressure is greater towards the centres of the sides than towards the corners.

We will now therefore assume the pressure to vary in the form of a parabola as shown in *Fig.* 3. We will take, as before, the total pressure on each side proportional to its length, so that the total pressure on each long side $=P_L=\frac{Wl}{2(l+b)}$ and that on each short side $=P_s=\frac{Wb}{2(l+b)}$.

The pressure at the centre of each side is therefore 1·5 p, p being the value given in equation (1). The resultant pressure along AB will act at the point Y, while that on the half sides AX, BX will be at the centroids of the parabolas—*i.e.*, $\frac{3l}{16}$ from X.

Therefore, taking moments about XX we have :

$$B = P_s \cdot \frac{l}{2} + \frac{2P_L}{2} \cdot \frac{3l}{16} - \frac{W}{2} \cdot \frac{l}{4}$$

$$= \frac{Wbl}{4(l+b)} + \frac{3Wl^2}{16(l+b)} - \frac{Wl}{8}$$

$$= \frac{Wl}{8(l+b)} \left\{ 2b + \frac{3l}{4} - (l+b) \right\}$$

$$= \frac{Wl}{8(l+b)} \left\{ b - \frac{l}{4} \right\} \qquad (9)$$

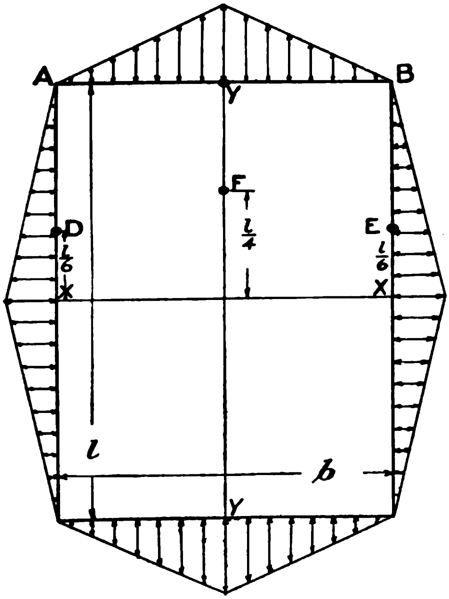


FIG. 3.

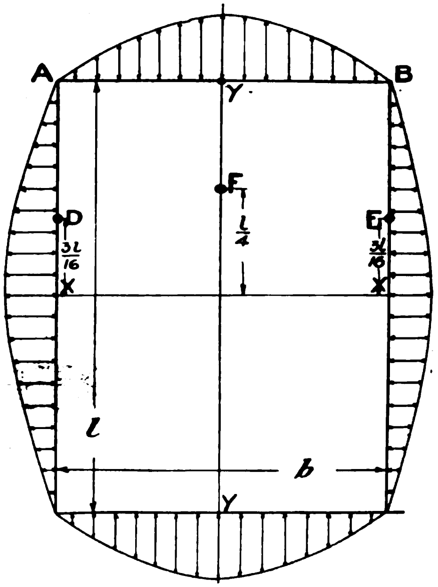


FIG. 4.

Neglecting side support, we have as before :

$$B = \frac{Wl}{8}$$

$$\therefore \text{ Slab coefficient for } XX = F_l = \frac{b - \frac{l}{4}}{(l+b)}$$

$$= \frac{1 - \frac{l}{4b}}{1 + \frac{l}{b}} \qquad (10)$$

Similarly, we get for YY by reversing l and b :

$$\text{Slab coefficient for } YY = F_b = \frac{l - \frac{b}{4}}{l+b}$$

$$=\frac{\frac{l}{b}-\frac{1}{4}}{1+\frac{l}{b}} \tag{11}$$

These results can be tabulated as follows:—

$\frac{l}{b}$	Slab coefficients	
	Short section XX F_l	Long section YY F_b
1	·375	·375
1·25	·306	·444
1·5	·250	·500
1·75	·205	·545
2	·167	·583

CASE III. PRESSURE VARIATION ACCORDING TO TRIANGLE.

In this case we will assume the pressures to be even more concentrated at the centres than in the previous case, and assume the pressure distribution shown in *Fig.* 4.

As before, we take total pressure on each long side $=P_L=\frac{Wl}{2(l+b)}$ and that on each short side $=P_s=\frac{Wb}{2(l+b)}$.

Taking the side pressures as acting at the centroids of the triangles, we get:

$$B=P_s\cdot\frac{l}{2}+\frac{2\cdot P_L}{2}\cdot\frac{l}{6}-\frac{W}{2}\cdot\frac{l}{4}$$

$$=\frac{Wbl}{4(l+b)}+\frac{Wl^2}{12(l+b)}-\frac{Wl}{8}$$

$$=\frac{Wl}{8(l+b)}\left\{2b-\frac{2l}{3}-(l+b)\right\}$$

$$=\frac{Wl}{8(l+b)}\left(b-\frac{l}{3}\right) \tag{12}$$

$\therefore$ Slab coefficient for $XX=F_l=\frac{b-\frac{l}{3}}{l+b}$

$$=\frac{1-\frac{l}{3b}}{1+\frac{l}{b}} \tag{13}$$

Similarly, by reversing l and b, slab coefficient for YY:

$$=F_b=\frac{\frac{l}{b}-\frac{1}{3}}{\frac{l}{b}+1} \tag{14}$$

These results can be tabulated as follows:—

$\frac{l}{b}$	Slab coefficients.	
	Short section XX F_l	Long section YY F_b
1	·333	·333
1·25	·259	·407
1·5	·200	·467
1·75	·151	·515
2	·111	·555

The Use of Slab Formulæ.

We have, in the foregoing treatment, developed three sets of slab formulæ, according to different assumptions of pressure distribution. Whichever of these is adopted, and we think that the parabolic distribution is the best of the three, it should be remembered that *the resulting calculations give only the average stresses across the section.* A very simple rough way of allowing for this would be to divide the span into three equal parts and to space the rods in the centre portion twice as close as in the ends. The slab coefficients given by the Grashof-Rankine rules are, on the other hand, for maximum stresses only and relate strictly to central strips. If, therefore, we use formulæ for average stresses we should remember that actually the stresses will be greatest at the centre; as a rough approximation we might take the stress variation as parabolic. The reinforcement, therefore, should be spaced closer together at the centre than at the ends to allow for this variation in stress.

For ease of comparison we will quote the values of the slab coefficients given by the Grashof-Rankine formulæ. They are:—

$\frac{l}{b}$	Slab coefficients	
	Short section XX F_l	Long section YY F_b
1	·500	·500
1·25	·291	·709
1·5	·164	·836
1·75	·096	·904
2	·059	·941

If we use the Grashof-Rankine figures, the calculations give the reinforcement required at the centre only, so that there is some loss in economy if the same reinforcement is maintained throughout.

We shall get these points more clear by a numerical example.

NUMERICAL EXAMPLE.—*A rectangular slab, 18 ft. long and 12 ft. wide, has to carry a uniformly distributed load of 200 lb. per sq. ft. Treating the ends as simply supported, and taking the slab as 5 ins. deep to the centre of reinforcement, find a suitable reinforcement in either direction.*

$$\text{In this case } \frac{l}{b} = \frac{18}{12} = 1·5$$

Free bending moment for long span $= \frac{Wl}{8} = \frac{(200 \times 18 \times 12) \times (18 \times 12)}{8}$

$= 1{,}166{,}400$ in. lb.

Do. for short span $= \frac{Wl}{8} = \frac{(200 \times 18 \times 12) \times (12 \times 12)}{8}$

$= 777{,}600$ in. lb.

(1) ***Parabolic Formula***: $F_l = \cdot 250$; $F_b = \cdot 500$.

$\therefore$ B.M. for short span $= 777{,}600 \times \cdot 500$.

$= 388{,}800$ in. lb. (1)

$\therefore$ B.M. for long span $= 1{,}166{,}400 \times \cdot 250$.

$= 291{,}600$ in. lb. (2)

Now for short span: $b = 18 \times 12$ and $d_s = 5$

$$\therefore \mu = \frac{B}{bd_s^2} = \frac{388{,}800}{18 \times 12 \times 5 \times 5} = 72$$

Reference to a diagram shows that for $t = 16{,}000$ lbs. per sq. in., $\mu = 72$ for ·5% reinforcement, so that the necessary amount of steel parallel to the short side is $\frac{\cdot 5 \times 5 \times 12 \times 18}{100} = 5 \cdot 4$ sq. in.

Taking ½ in. bars of area ·196 sq. in., we should require $\frac{5 \cdot 4}{\cdot 196} = 28$ say.

These could be arranged with the centre 12 at 6 in. centres, and the remaining 16 at 9 in. centres.

For long span: $b = 12 \times 12$ and $d_s = 5$

$$\therefore \mu = \frac{291{,}600}{12 \times 12 \times 5 \times 5} = 81$$

From our diagram we see that this is given by about ·57% reinforcement.

$\therefore$ Area of steel required parallel to the long side $= \frac{\cdot 57 \times 5 \times 12 \times 12}{100}$

$= 4 \cdot 1$ sq. in.

$\therefore$ Using ½ in. rods of area ·196 sq. in., we shall require $\frac{4 \cdot 1}{\cdot 196} = 21$ rods.

Say 9 rods at 5 in. centres at the centre, remainder at each side at 8 in. centres.

(2) ***Grashof-Rankine Formula:***

$F_b = \cdot 836 \qquad F_l = \cdot 164$

$\therefore$ B.M. for short span $= 777{,}600 \times \cdot 836$.

$= 650{,}000$ in. lb. nearly (3)

$\therefore$ B.M. for long span $= 1{,}166{,}400 \times \cdot 164$.

$= 191{,}000$ in. lb. nearly (4)

$$\therefore \text{for short span } \mu = \frac{650{,}000}{18 \times 12 \times 5 \times 5} = 120$$

This requires 1·42% reinforcement; it would really be better to increase the depth.

$\therefore$ Area of steel required $= \frac{1 \cdot 42 \times 5 \times 12 \times 18}{100} = 15 \cdot 3$ sq. in.

for long span $\mu = \frac{191{,}000}{12 \times 12 \times 5 \times 5} = 53$. About ·38% will give this.

$$\therefore \text{ Area required} = \frac{\cdot 38 \times 5 \times 12 \times 12}{100} = 2{\cdot}7 \text{ sq. in.}$$

It will be seen that the Grashof-Rankine formula makes a greater difference between the relative reinforcements required in the two directions than does our suggested parabolic formula.

A BENDING-MOMENT PROBLEM.

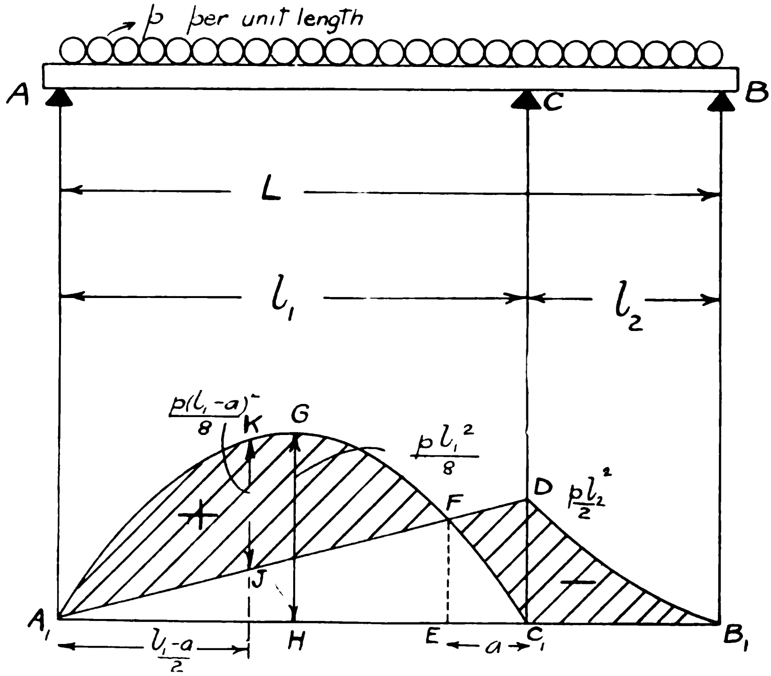
"*The best position for the prop of a uniformly loaded beam supported at one end and overhanging the prop at the other.*"

In this problem no new principles are advanced, but the problem is not to be found in the text-books with which we are acquainted, and will probably be of interest to the students among our readers.

A beam AB on span L is supported at one end A and overhangs the support C at the other end; we wish to find, with a uniformly distributed load, the position of the support C which will be most economical—*i.e.*, give the least bending-moment.

If the length of the overhanging portion BC is l_2 and the distance AC is l_1, the B.M. diagram will be as shown shaded in the figure; the portion B_1D is a parabola tangential at B_1 and is the familiar diagram for a cantilever with a uniformly distributed load; the portion AGC_1 is a parabola of height $\frac{pl_1^2}{8}$, the usual one for a freely supported span AC; and A_1D is a straight line.

The maximum positive B.M. will be given by KJ, which will be equal to



$\frac{p(l_1-a)^2}{8}$ since the B.M. between the point A_1 and the point E of contraflexure will be the same as for a freely supported beam of span A_1E, and the maximum negative value is given by C_1D. Our problem resolves itself into find the position of C to make JK or C_1D the least possible.

Now, if you move the point C to the left, C_1D will increase and KJ will decrease, whereas if C moves to the right the converse happens. If, therefore, $C_1D = KJ$, movement of C will increase one or the other, so that the least value of either occurs when they are equal.

This gives

$$\frac{p(l_1-a)^2}{8} = \frac{pl_2^2}{2}$$

$$\textit{i.e.,}\quad (l_1-a)^2 = 4l_2^2$$

$$\text{or}\quad (l_1-a) = 2l_2 \tag{1}$$

Again, by the property of the parabola

$$EF = p\left(\frac{al_1}{2} - \frac{a^2}{2}\right) \tag{2}$$

This can be found by taking the B.M. at E for the span A_1C_1; also by similar $\triangle$'s.

$$\frac{EF}{C_1D} = \frac{A_1E}{A_1C_1}$$

$$\textit{i.e.,}\quad EF = \frac{pl_2^2}{2} \times \frac{l_1-a}{l_1} \tag{3}$$

Combining (2) and (3) we get:

$$\frac{pa}{2}\left(l_1-a\right) = \frac{pl_2^2}{2} , \frac{l_1-a}{l_1}$$

$$\text{or,}\quad a = \frac{l_2^2}{l_1} \tag{4}$$

Putting this result in (1) we get:

$$l_1 - \frac{l_2^2}{l_1} = 2l_2$$

$$\textit{i.e.,}\quad l_1^2 - 2l_1\,l_2 - l_2^2 = 0 \tag{5}$$

The solution of this quadratic equation gives, taking the positive root:

$$\frac{l_1}{l_2} = \frac{2+\sqrt{4+4}}{2} = 1+\sqrt{2} = 2{\cdot}414$$

$$\therefore\ 1 + \frac{l_1}{l_2} = \frac{l_1+l_2}{l_2} = \frac{L}{l_2} = 1 + 2{\cdot}414 = 3{\cdot}414$$

$$\text{or,}\quad l_2 = \frac{L}{3{\cdot}414} \qquad \textit{i.e.,}\quad l_2 = {\cdot}293L$$

In this case the maximum B.M. will be equal to

$$\frac{pl_2^2}{2} = \frac{p\times({\cdot}293L)^2}{2} = \frac{pL^2}{23{\cdot}3}$$

It will be of some interest to compare this result with that which would occur if each end were overhung and the supports were placed so as to give the least B.M. for this condition.

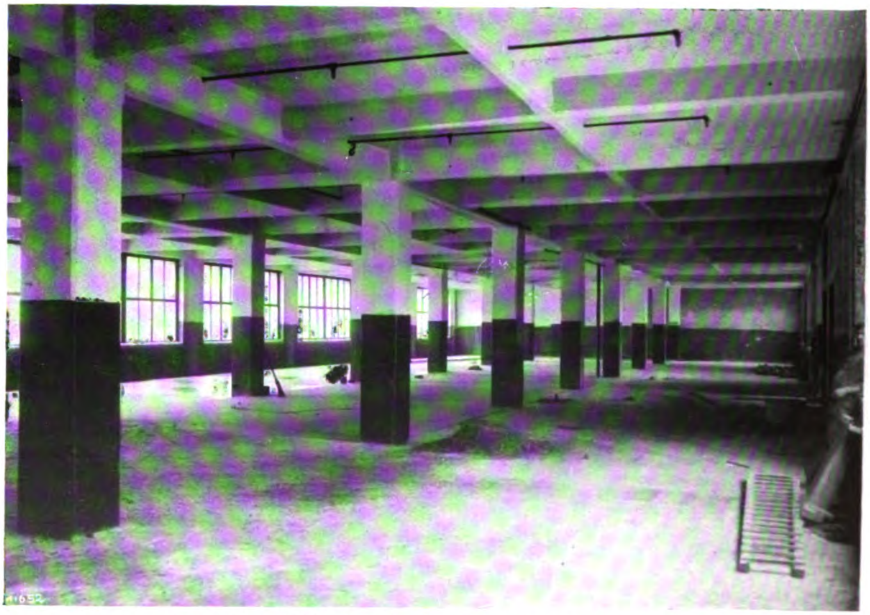
In this case the best condition is given when the overhang is $\cdot 207L$. This gives a maximum B.M. equal to $\frac{p\times({\cdot}207L)^2}{2} = \frac{pL^2}{46{\cdot}6}$ approx., which is half that for the previous case.

BUILDING FOR THE BELL TELEPHONE MANUFACTURING COMPANY AT ANTWERP, BELGIUM.

An argument often brought forward against the use of Reinforced Concrete for buildings where elaborate machinery is needed is, that it is not suitable for this purpose. In the present example it is shown that any difficulties that may present themselves can be well overcome.—ED.

A LARGE building was recently erected almost entirely in reinforced concrete for the Bell Telephone Manufacturing Company at Antwerp.

The site of the new building, which is intended for a factory, is situated at Rue Diercxsens, Antwerp. This building is composed of a principal body having in plan the shape of a rectangle 72·93 m. in length and 16·78 m. in width (243 ft. by 55 ft. 10 in.). On the long side of the building, facing toward the courtyard, the new building includes also a rectangular portion which will constitute the beginning of a future extension. The dimensions of this portion are 16·78 m. long by 3·58 m. wide (55 ft. by 12 ft.).

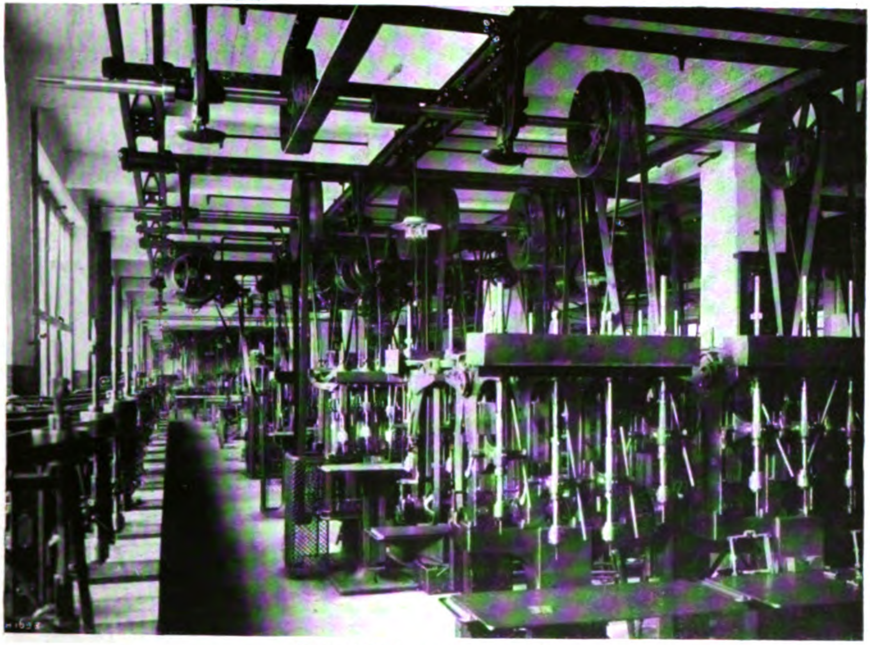


Interior View of Machinery Room before Installation of Machinery.
REINFORCED CONCRETE BUILDING FOR THE BELL TELEPHONE MANUFACTURING CO., ANTWERP.

The building is composed of a ground floor built over a basement, four upper storeys, and a flat roof. The floors are supported by four lines of pillars in reinforced concrete—namely, two central lines, one line facing the street and another line facing the courtyard at the back of the building.

The portion of the future extension is supported by five pillars constructed sufficiently strong to support the load which will come upon them when the extension is erected. The four posts along the side of the adjoining building are also constructed in such a manner as to be strong enough to support the load of any future extension which may take place towards this adjoining building.

The various floors are accessible by means of two staircases and two lifts. One of the staircases and one of the lifts is situated on the side of the present factory, and the other staircase and lift are situated on the side of the future extension towards the courtyard.



View of Machinery Room installed.

Reinforced Concrete Building for the Bell Telephone Manufacturing Co., Antwerp.

The pillars are resting on foundations entirely in reinforced concrete, spread on the ground in such a manner as to produce a pressure not greater than 2 kg. per sq. m. (1 ton 16½ cwt. per sq. ft.).

It was originally intended to provide ordinary concrete foundations spreading the weight of the pillars over the ground at the rate of 3 kg. per sq. m. (2 tons 15 cwt. per sq. ft.). After the ground was excavated, however, to the level of the foundations, it was found that the subsoil was composed of fine sand mixed with clay, and the presence of water at this level had the effect of transforming the subsoil into more or less liquid mud. The difficult problem of spreading heavy loads coming from the pillars on to this very bad ground was satisfactorily solved by the adoption of spread foundations in reinforced concrete. To facilitate the construction of these foundations it was necessary to surround them by means of wooden sheet piles, in order that the reinforced concrete work should be executed in the dry. These sheet piles were withdrawn after the foundation work was completed.

The ground floor is calculated for a superload of 2,200 kg. per sq. m. for the slab (4 cwt. per sq. ft.). The beams, however, are calculated for a superload of 1,100 kg. per sq. m. (2 cwt. per sq. ft.). This different rate of loading on the beams and slabs was necessitated by the fact that the machinery is liable to be shifted to any portion of the floor slab, thereby creating concentrated loads. The first, second, third, and fourth floors are all calculated for a superload of 850 kg. per sq. m. (174 lb. per sq. ft.). The flat roof has been calculated for a superload of 200 kg. per sq. m. (44 lb. per sq. ft.). Over and above the superloads indicated, the dead weight of the construction and composition flooring, weighing 84 kg. per sq. m., has been taken into account for the ground, first, second, third, and fourth floors, and a layer of asphalt weighing 20 kg. per sq. m. has been provided for the roof.

Exterior View.

Reinforced Concrete Building for the Bell Telephone Manufacturing Co., Antwerp.

River sand and hard broken stone were used for the making of the concrete. The materials were mixed in the proportions of 300 kg. of cement, ·400 cu. m. of sand and ·800 cu. m. of gravel (approximately 1, 2, 4 in parts). Concrete test cubes made with these materials and with this mixture gave excellent results of over 2,400 lb. per sq. in. after twenty-eight days.

The steelwork is entirely composed of round bars of mild steel.

The wall of the front elevation facing the street and the wall of the back elevation facing the courtyard were constructed in brickwork, having a thickness of 1 ft. 6 in. from the first floor to the roof, and 1 ft. 10 in. from the foundations to the first floor. The back wall overlooking the court is faced with white enamelled bricks for the reflection of light. These brick walls are supported at each floor by reinforced concrete lintels spreading the loads on to the pillars. The walls at each floor, therefore, do not carry any load, and their thickness is in accordance with the Belgian regulations.

Fig. 3 shows a general view of the elevation, which has been designed by the architect with the object of forming a suitable continuation of the existing buildings. The two other views show one of the floors previous to the fixing of shafting and machinery and after the machinery has been placed in position. *Fig.* 2 shows that there is no particular difficulty in adapting elaborate machinery to the floors and pillars of a reinforced concrete factory, and, in spite of the heavy vibration due to this machinery, scarcely any vibration is perceptible on the floors themselves. Some of the punching machines resting directly upon the ground floor weigh over nine tons each.

A special method of fastening the machinery to the floor was adopted in order to prevent cutting holes in the composition floor and in the concrete. This process consisted in fastening the machines to the floor by means of pieces of felt about ½ in. thick dipped in a special compound, which securely sticks the felt to the foot of the machine and to the floor. Whilst this process does undoubtedly prevent, to a certain extent, the vibration of the machines from being transmitted to the floor, it was not adopted with this idea in view, and, apart from this, no other precautions, such as india-rubber sheeting or other material, have been taken to reduce the vibration. Needless to say, as usual in most factories, any of the machines are liable to be shifted from one place to another. This, however, can be done without any difficulty.

The work was carried out under the supervision of Mr. G. A. Pennock, plant engineer. The general plans of the building were prepared by Mr. J. L. Hasse, architect of Antwerp, and the plans for the reinforced concrete work were executed by Messrs. Edmond Coignet, Ltd., of 20, Victoria Street, London, S.W., the entire contract being carried out by Messrs. G. Hargot and R. Somers, of Antwerp.

RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

RECENT PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

THE DESIGN OF STEEL AND REINFORCED CONCRETE PILLARS, WITH SPECIAL REFERENCE TO SECONDARY AND ACCIDENTAL STRESSES.

By OSCAR FABER, B.Sc.

The following is an abstract from a paper read before the Concrete Institute at their 48th Ordinary General Meeting.

JOINTED CONSTRUCTION.

THE author divided his paper into two sections. He first dealt with jointed construction, such as structural steel; and, secondly, with monolithic construction, such as reinforced concrete. In dealing with the case of a girder resting on the end of a steel stanchion, he stated that in several drawing offices he knew as a fact that the construction in such a case would be treated as centrally loaded. He proceeded to argue that this was not so, because, when a load was applied to the beam, it would deflect, and the end originally horizontal would assume a certain slope, and therefore one of two things would happen—namely: (*a*) the end of the girder would lift, in which case the whole load would be carried on one flange, so causing eccentric loading; or (*b*) the column must be constrained to adapt itself to the slope of the girder, in which case a bending moment would be introduced into the stanchion by such constraint.

In this way he showed that increases in strains of 140 and 480 per cent. respectively were obtainable.

Mr. Faber took, secondly, for consideration the case of a girder resting on an angle bracket. He argued that if an ordinary bracket were used the action would not be very far from the face of the leg of the angle, since the horizontal leg of the angle would not be strong enough to resist the bending moment which would be produced in it. It followed, therefore, that, although the horizontal leg of the angle served a useful purpose in connecting the girder to the stanchion, it must not be thought capable of supporting it. In effect, the construction became dangerous if the clearing between the face of the stanchion and the edge of the girder exceeded the thickness of the angle.

The author supposed there were few engineers present who would assert that this limiting clearance was never exceeded in practice, and an engineer had to carefully consider whether it was desirable to employ this type of bracket except for quite small reactions. He next considered a stiffened bracket.

Confining attention to cases where the workmanship was good, he assumed that the stiffening angles had been machined or forged to fit the angle bracket perfectly, and that the bracket was initially horizontal. It followed that when the girder deflected there was a tendency for it to rest on the outer edge of the bracket, and for very small loads there was no doubt that this actually happened. As the load increased the outer edge of the stiffeners yielded appreciably, and a greater area supported the load, the reaction gradually approaching the face of the column. The author's practice was to make the web of the stiffeners sufficient in area to carry the reaction under a uniform stress of $7\frac{1}{2}$ tons/in².

In calculating the resistance he ignored a large area of steel in the flange of the stiffeners, and in the vertical leg of the angle bracket, because (*a*) the clearance between the face of the stanchion and the end of the girder might be sufficient to prevent bearing on this steel; (*b*) even if it was not, this material could not be stressed appreciably until the stiffener webs are greatly overstressed.

In any case the difference in cost between good and bad brackets was an extremely small percentage of the cost of the steelwork, and a smaller one of the cost of the building, and he declined to endanger the " ship " for what, in this case, might be fairly described as a " ha'porth of tar."

It has long been recognised in good practice that the machining of the ends of stanchions was of the first importance. Yet there were at least two constructional works in London which, with a view to economy, omitted this item of workmanship, and were erecting considerable tonnages of stanchions with the ends left so that the upper tier had contact with the lower tier over the width of one plate only, the remainder of the section having varying clearances, often amounting to $\frac{1}{8}$ in. The stress was still gaily calculated as uniformly distributed, and it had been explained to the author that " steel is a ductile material which would yield and flow " and perform other convenient antics, " until the stress was uniformly distributed." The effect of loading such a stanchion was to cause the plates to slide past one another, and to partly shear through the rivets. Even where stanchions are machined a careful engineer must satisfy himself that they were machined truly square. Architects should bear in mind also that, apart from the danger involved in these practices, the yielding of stanchions and brackets before they obtain their bearing involved unknown and unintended stresses on the stonework, and to the author's knowledge many a beautiful and costly façade and interior decorative work had been badly cracked by bad steelwork details and workmanship.

From the consideration of Case 1 it would appear to follow that it was desirable to make these joints somewhat flexible, and occasionally this was so. If buildings were braced with diagonal braces he should say without question that stiffness of connections should be avoided.

Unfortunately, such bracing had obvious objections, and the whole stiffness of practical buildings against wind lay in the stiffness between beams and stanchions.

There was, therefore, no alternative but to make the joints stiff and to make the necessary allowance for these secondary stresses in the design of stanchions.

This might be onerous, both in requiring extra labour and an increase in material, but a conscientious engineer would grudge neither the one nor the other.

Mr. Faber then dealt with the design on cleats. A common method of calculating the safe reaction of a cleat was to take it as the sum of the resistances of the rivets, the effect being to neglect the very appreciable stresses due to bending.

Dealing with the bracing of pillars, Mr. Faber said that it was well known that pillars failed by buckling, and that their stress was to be determined with reference to their l/g. This phenomenon was fairly well understood, and there are sufficient experimental data available to make the design of pillars, with reference to what he might call primary buckling, a comparatively simple matter. The phenomenon to which he referred was that of secondary buckling, in which the pillar, instead of buckling as a whole, fails by the individual buckling of its component members. On this subject there appeared to be practically no experimental data and practically no formulæ or rules for the guidance of a designer. The importance of this problem might be gathered from the fact that bad design in the matter of bracing in pillars was certainly responsible for the two greatest failures in recent years—the Quebec Bridge of 1907 and the gasholder in Hamburg.

MONOLITHIC CONSTRUCTION.

Mr. Faber then proceeded to the second portion of his paper, treating of monolithic construction and the eccentricity of beam reactions on pillars therein. Whereas in steel construction the eccentricity was very definite and easily calculated with most common types of brackets, with reinforced concrete the eccentricity could only be calculated from considerations of elastic flexure, and the problem was a much more difficult one.

There was, however, no longer any excuse for claiming ambiguity, since the problem had been analysed very completely in " Reinforced Concrete Design," and numerical examples fully worked out.

The author took as an example the case of the outside column of a building, working it out in detail, showing very great increases in stress over the values as ordinarily calculated. If thoughts of eccentricity were banished, either from ignorance or under stress of competition, the actual maximum stress would have been 1,300 lbs./in^2.

It is interesting to note that the outside pillar in good design did not suffer much reduction in size up through the last three tiers. This was in accordance with the best practice in steel-frame buildings.

In conclusion, Mr. Faber said that without suggesting for a moment that the engineering staffs of several constructional firms were not fully as efficient as many consulting engineers, he did feel that the system of competitive designs and lump sum prices penalised good designing by such firms and secured the work to those responsible for the most risky design. The only correct system, in his opinion, was for the architect to entrust the design to an engineer who had his confidence and to invite tenders on the design which he prepared. The architect and building owner were then likely to obtain a sound construction, and if they used their discretion in the choice of the engineer the work would not cost more than the minimum consistent with safety.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THE USE OF CONCRETE IN THE DESIGN OF MINE SHAFT LININGS.

By WILLIAM ARCHIE WELDIN.

The following is an abstract from a Paper read before the Engineers' Society of Western Pennsylvania; we have reproduced those portions relating to the use of concrete in shaft linings. Our abstract is taken from the Proceedings of the Society, Vol. 29, No. 9.

THE primary function of a shaft lining is, of course, to keep the excavation open, supporting the sides, and resisting any tendency to collapse. In the case of hoisting shafts, it is also required to safely guide and support the cages, stairways, pipes, etc. Partitions between hoisting and ventilating compartments, when required, are also a proper part of the lining. In certain cases the lining is required to exclude water.

In their anxiety to be on the safe side, some advocate making the lining capable of resisting a static head equal to the full depth of the shaft; giving for a reason, to quote from two recent articles : " The concrete lining should exclude the water entirely, and hence must be designed to bear very great pressure at considerable depth "—and—" The concrete should keep out the water completely, because weep holes are not desirable."

This requirement would result in linings of great thickness, heavily reinforced, and would require quite unusual expense in constructing shafts. In fact, shafts so proportioned would seem quite unreasonable to one experienced in such works. It may be thought that all shafts should exclude the water so as to reduce the cost of pumping. Even this consideration would call for a head extending only to the first impervious stratum, reduced by the hydraulic gradient of the material penetrated. Usually, the surface water is the only inflow of any consequence encountered, and it is often no more than the requirements of fire protection, sprinkling, etc., demand.

Until within the last ten years, shafts in America were always lined with timber. In the course of many years' experience with this material, designs practically identical in all essential features have been almost universally adopted. These designs are eminently satisfactory, representing as they do the accumulated experience of many men. However, the risk of fire, unsatisfactory life, increasing cost, and decreasing quality of commercial timber have brought about the substitution of concrete and other materials, which require different treatment, and open up afresh the entire problem of design.

It is to be expected that the wooden linings of shafts for a modern mine will require renewal at least twice in the life of the mine. The cost of such renewal is of course, very much greater than the first cost. Besides the increase in cost of timber which may be expected in the future, the cost of renewal of the old timber and substitution of the new is high, as the operation must be carried on piecemeal and without interfering with use of shaft. In spite of precautions, the operation of renewal of lining has been known to result in the collapse of the shaft, entailing additional expense. Of course, such a shut-down, whether due to fire or other cause, means a large loss. The fixed expense of keeping the workings open and drained, and the salaries of a large modern organisation, make a prolonged period of idleness little short of disastrous.

The proportions of timber linings have gradually come to be settled by common consent. Commercial sizes arbitrarily adopted are used, of course, and these allow for decay and other defects as well as the sections necessary to resist external forces. Concrete linings, on the other hand, are not limited to conventional thicknesses and do not require large excess to provide for deterioration. An arbitrary thickness allowing sufficient space back of the form for good workmanship in depositing the concrete, should be shown in the design, and 12 ins. is suggested for this thickness. In sinking, all irregularities should be outside the neat line thus shown, so that the average thickness will be much greater than the minimum. In passing through clays and friable shales, the scaling of the walls naturally increases the thickness, thus providing increased strength at such points.

THE SHAPE OF A SHAFT.

The usual timber-lined shaft is rectangular in section, this being the outline best suited to the material. The recent introduction of concrete, however, a material suited to any shape, has thrown open the question as to what is the best outline of cross section. The subject "Rectangular *v.* Circular Shafts" has occupied considerable space in current literature. The circular shape offers great advantages, and, for ventilation shafts, it is unquestionably the best shape to use. As the circle is the figure of least perimeter for a given area, it follows that a circular shaft will require the least material for lining and oppose the least frictional resistance to the air current of any possible shape. A further saving in material, particularly in cases where pressure is to be feared, is due to the fact that this shape is strongest in compression. There is an advantage in sinking, in that there is no tedious process of cutting out corners. In clay and other formations, which tend to fall into the excavation, there is a considerable saving due to the fact that the curved walls will stand much better than straight ones.

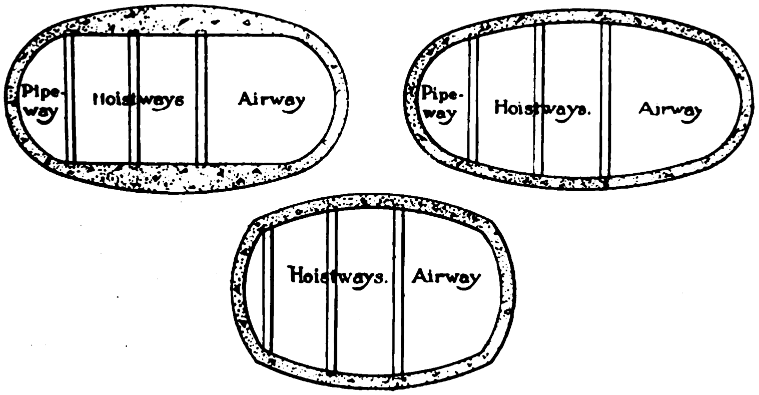


FIG. 1.

In the case of ventilating shafts, there are no difficulties to offset these advantages. These same advantages are urged by many in favour of circular shafts for hoisting, and in Europe this is the favourite form. In the writer's opinion, however, there are sufficient reasons why the circular form should not be used in the United States, however successful it may be abroad. These reasons lie mainly with differences in the hoisting practice. On account of the underground conditions, the European mine car is small, being commonly limited to about ½ ton capacity, while in America cars of three and four tons are common. In Europe cages of 2, 3, or 4 decks are used when a large capacity is required, this practice being justified by the great depth of many of the shafts.

Early designs of concrete shafts in America indicate an effort to compromise between circular and rectangular forms. Apparently a fear of excessive pressure prevented the use of straight lines, and there resulted various forms as shown in *Fig.* 1. These arched forms are assumed to be stronger than rectangular shapes. This is true where water pressure is to be resisted in rock excavation. The fact seems to have been overlooked, however, that these arches can be depended on only when they have solid abutments. This is not usually the case, and where it is there is generally no need of their strength, as the walls of the excavation are self-supporting.

In answer to the question: "What shape should be used for concrete-lined shafts?" the author said that ventilation shafts should be circular, and hoisting shafts rectangular. Where the requirements of ventilation necessitate an area greater than that required for hoisting, such area should be enclosed by a rounded end.

DRAINAGE.

As already mentioned, it has frequently been argued that all concrete linings should exclude water from the shaft. It is, however, very common practice to construct drainage systems behind the lining for the purpose of relieving the lining of all such hydrostatic pressure.

Water rings are principally relied on to accomplish this result. These are cavities formed in some suitable stratum below the principal points of inflow, and extending entirely around the shaft. They are large enough for a man to crawl through, and doors are formed in the lining to give access to them. A recess is formed in the lining to intercept any seepage which may flow down the face of the lining and turn it into the ring. The bottom usually consists of a paved gutter having a strained outlet into a pipe extending down the shaft to the sump. This pipe is frequently connected to the fire or sprinkling lines of the mine.

In concrete-lined shafts the water rings are generally supplemented by several vertical lines of farm drainage tile placed back of the lining. The joints are surrounded with broken stone to exclude the concrete.

MATERIALS FOR LININGS.

Besides concrete, already mentioned as a substitute for timber, brick and steel are occasionally used. Cast iron is well liked in Europe, though little used in America. Separately moulded concrete blocks and "timbers" have also been used.

CONCRETE BLOCKS.

Nearly all concrete linings are cast in place behind steel, or wood forms; but there have been some interesting cases of linings cast in whole, or in part, on the surface.

A circular shaft 133 ft. deep and 13 ft. 4 in. diameter was recently sunk by the United Collieries of Charleroi, Belgium.* This lining consists of an inner layer of segmental concrete blocks, 30 in. high, 3·2 in. thick, and 14 to the circle. Between the blocks and the walls of the excavation, concrete is poured, making a wall thickness of 1 ft. 7 ins. The blocks are reinforced and provided with dowels holding the successive rings in line and ring bolts projecting into the concrete backing. Through the latter is laced a zig-zag reinforcing of round rods which ties the blocks to the mass concrete. It is stated that the cost was $8.65 per lineal foot, and that this lining is

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*Translated and abstracted from "Annales des Mines de Belgique" by E. P. Buffet, published in *Coal Age*. June 21st, 1913.

equal in strength to one of masonry 32 in. thick which would have cost $13.50. Mixture 6 gravel, 3 sand, 3 cement.

CONCRETE TIMBERING.

Separately moulded concrete members, designed to be substituted for framed timbers and erected in the same way, have also been used. *Fig.* 2 shows such a lining as installed in the inclined shaft of the Ahmeek Mining Co., Michigan. The success of this installation and the well-known advantages of this type of structural construction make it well worthy of serious consideration. Such structural concrete would seem to offer special advantages for rapid work. The members can be moulded in advance of sinking, and if the erection plant is provided to properly handle these heavy pieces, there is no reason why such lining cannot be placed almost as rapidly as timber.

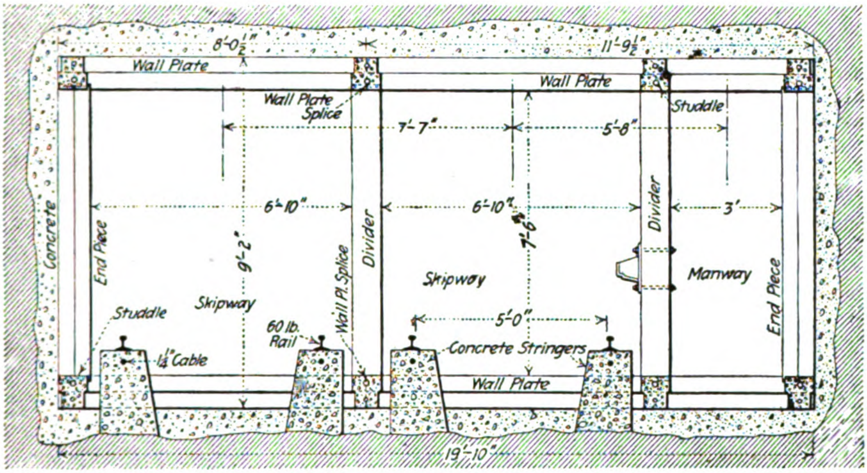


FIG. 2.

Another necessary provision at the coping is a support for landing rails close to the cages. In the case of circular shafts this is usually provided by steel beams forming chords parallel to the cage ends.

BUNTONS.

The introduction of concrete for lining has brought forward an interesting variety of buntons, or cross members, for guide support. The first concrete shafts were provided with wooden buntons of the same section as were in use in timber linings. This was early recognised as begging the question, however, and the present various sections have been advanced as substitutes. Steel beams and channels suggested themselves, but experience with corrosion, in surface structures, naturally caused apprehension as to the life of these members. As explained elsewhere, this apprehension is largely unfounded, but the fact remains that structural steel in such a situation cannot have the life of the concrete lining, and to that extent that design is inconsistent.

Buntons of I-beams and H-beams of various sizes have been made, as well as beams and channels covered with concrete. While the writer has had no experience with the latter, he is inclined to fear that the life of the concrete covering, usually thin, will prove unsatisfactory, and would prefer a reinforced section.

A curious example of conservatism is shown in the fact that practically all designers have failed to realise that, as the standard timber lining breaks joints at the buntons, the latter are proportioned as struts, and also that the arbitrary spacing of rings in the timber lining is as much for convenience in handling the verticals and placing the plank lagging as for needed strength; whereas, in concrete, there is no such breaking of joints, and the end details usually adopted prevent any real strut action.

GUIDES.

Wooden guides are generally used, even in concrete shafts, long leaf yellow pine of the best grade obtainable is specified. The pieces are obtained as long as possible, and may be spliced by any of the well-known timber splices. A butt joint with a substantial splice piece is preferable. The guide should be dapped over the buntons deep enough to give a safe bearing pressure on the dap when the action of the safety device brings on the maximum load. The size sanctioned by best practice is 6 by 8 ins. The longest diameter should be placed on the long diameter of the shaft in order to give large bearing to the safety device. Guides should be secured by countersunk through-bolts, not lag screws as are sometimes used.

STAIRWAYS.

Stairways are generally required by law, unless a second hoist is provided as an escape way. These are generally placed in a compartment of the hoist shaft. This is the most convenient arrangement, as the stairs communicate directly with the workings. Stairs are objectionable in air shafts on account of their resistance to the air current. The velocity of the air also makes travel on them highly inconvenient.

Until recently, shaft stairs were generally built of wood. On account of fire risk this practice should be eliminated, particularly in concrete shafts. Many stairs have been built of structural steel. Here we encounter the same objections as are made to steel buntons, but it is hardly feasible to resort to few members of increased thickness. However, the cost of renewal does not include in this case the large extra charges mentioned in the case of lining renewal, and such renewal does not affect the output.

The construction of light stairways in reinforced concrete is now well understood, and it is suggested that shaft stairs be built of this material. In all but the shallowest shafts it is desirable to build the steps on rather a low pitch with frequent landings, on account of the great labour required to climb out of a deep shaft; 7½ ins. rise and 9½ ins. tread are recommended.

PARTITIONS.

In general it is desirable for large mines to sink a separate circular shaft for the sole purpose of conducting the ventilating current to the workings. This may be provided with a hoist operating between rope guides to serve as a second outlet or escape way, access to the shaft being provided by air locks at the top or bottom, or an escape way may be provided by some other outlet. Perhaps the best arrangement for large mines is a plain circular shaft for ventilation, a hoisting shaft for coal only, and a third shaft for hoisting men and materials.

However, it is a common practice to combine in one shaft both hoisting and ventilating compartments. These must be separated by tight partitions. In the case of wood lining, the purpose was generally served by lining the air compartment all around with two layers of tongued and grooved flooring, having tar paper between. This same construction was at first applied to partitions in concrete shafts. A modification of this practice has been adopted by substituting a four-inch reinforced concrete curtain for the second layer of sheathing. This curtain extends into the concrete lining, filling a *V*-shaped groove cut by hand. At the Universal Mines of the Bunson Coal Co., built some years later, the wood sheathing was discarded and a five-inch reinforced concrete partition, stiffened with six-inch steel channel buntons every five feet, was cast after the lining was complete. It entered grooves cast in the lining. Such a partition is certainly more consistent in a concrete shaft than any scheme involving large quantities of wood. It is doubtful, however, if the use of structural sections as reinforcement in the stiffener is justified on account of the danger of separation on shrinkage of the concrete. Stiffeners cast in place, and reinforced with unit frames of rods, would probably be more satisfactory, and it is possible that a wall of uniform thickness sufficient to give the required stiffness would be more economical.

If thin stiffened partitions are used, they could probably be best formed by plastering cement mortar on one of the several patent combined metal stud and lath fabrics.

SHAFT BOTTOM.

It is customary to build brick or concrete arches to protect the main headings at the foot of a shaft, and it is a simple matter of form construction to make a junction of these with the lining.

In a recent construction, the junction of the circular ventilating shaft with the heading was made by erecting a half section of the shaft form in an inclined position forming a 45 deg. elbow, thus reducing the resistance to the change in direction of the air current.

A SUGGESTED DESIGN.

The design shown in *Fig.* 3 is offered by way of suggestion. It is essentially a rectangular shaft, the curved end being designed to include any area required for pipes and ventilating current. This area may varv from nothing to a large semi-circular compartment, according to conditions.

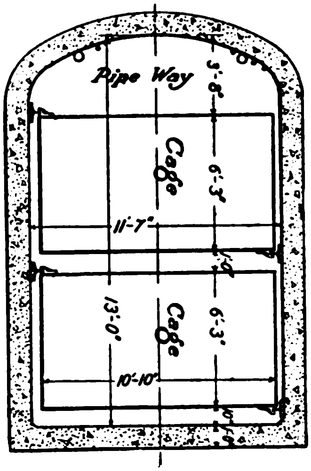


FIG. 3.

In the case where no air way is required, if the modern practice of leading pump and compressed air lines down separate boreholes is followed, the shaft may be rectangular, being symmetrical about the centre between cageways, and only long enough to include the end guides. The space between the cage and end wall should be ample to contain all wires and pipes required. If necessary, the end guides can be spaced a little away from the end walls to allow more room for pipes. Pipes may be supported directly on the concrete walls, by means of one of the several types of patented devices intended for attaching shafting, etc., to concrete buildings.

Steel guides are suggested, supported directly on the shaft wall, using cast steel slippers attached to the corners of the cage at top and bottom.

In order to facilitate the accurate lining up of these guides, which should be done with the help of a template, or gauge, in addition to the plumb lines, a wooden block is provided.

If this use of guides at the cage corners be thought too much of an innovation, the guides may be secured directly to the straight end wall, thus eliminating one or two lines of buntons as the case may be.

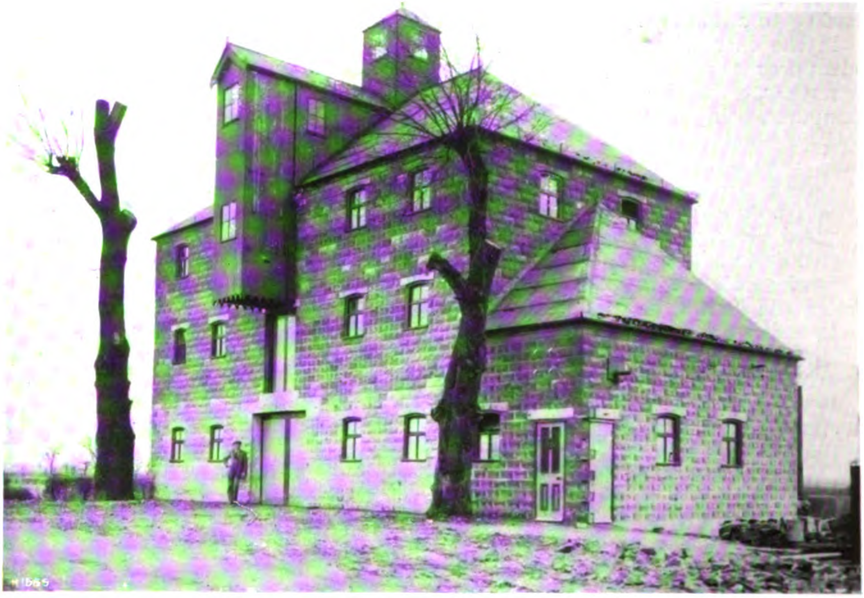
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

CONCRETE ON THE FARM.

WE have frequently given examples in this Journal of the utility of concrete for the farm and the estate, and its advantages have been shown not only in the United States, where concrete is so widely used in agricultural districts, but also in our own country, although over here a certain amount of reluctance still prevails to employ the material as frequently and freely as it might be used. It is nevertheless an important factor in helping to solve the question of securing sanitary and healthy buildings in our agricultural districts.

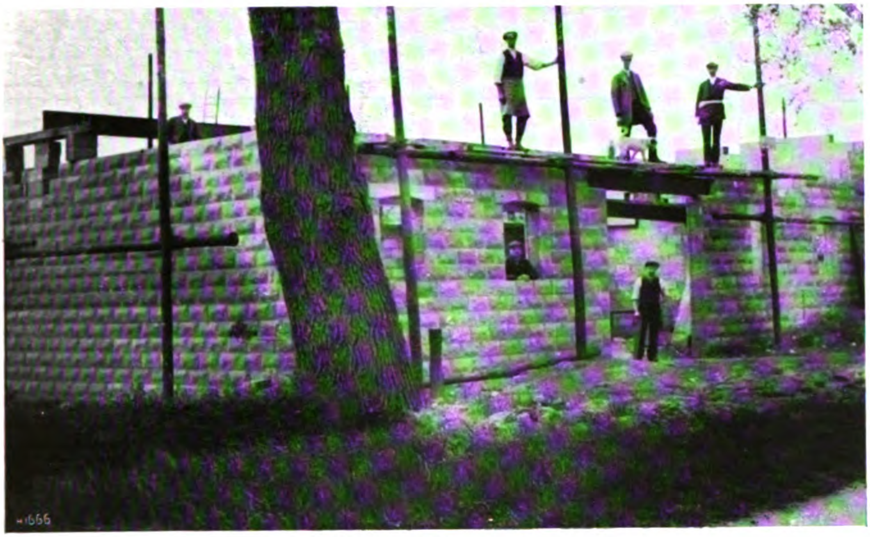


View of Finished Mill.
CONCRETE ON THE FARM.

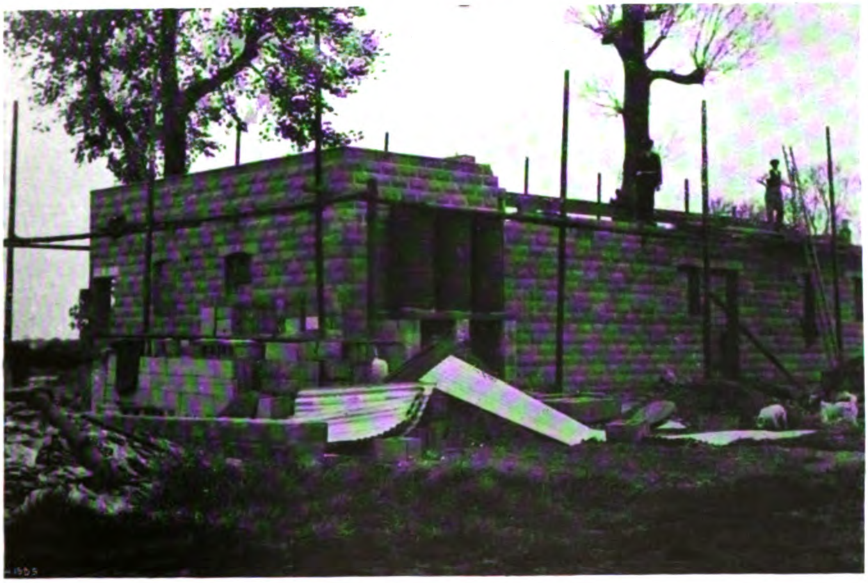
An interesting example of the use of concrete in rural districts is here illustrated. The building has been erected on the farm of Messrs. E. W. Farrow and Son, of Spalding, Lincolnshire. In appearance the structure resembles a stone building, and it is to be used as a granary, warehouse, and grinding mill. In its erection concrete blocks, made on the site on a "Springfield" machine by Messrs. Goodwin, Barsby and Co., of Leicester, have taken the place of bricks, and it must be admitted that the result justifies the innovation.

Hollow concrete blocks have been used, ballast and sand being used for the middle of the blocks, and for the fine blocks a mixture of sand and cement in the proportion of 2½ to 1 has been used, and the coarser work has been done with a mixture of 5 of gravel to 1 of cement.

There is a 5-in. hollow in the centre to ensure dryness of the building, and in order to effect economy the blocks are 16 in. long and 8 in. deep. These dimensions vary a little on some of the floors.



Mill in course of construction.

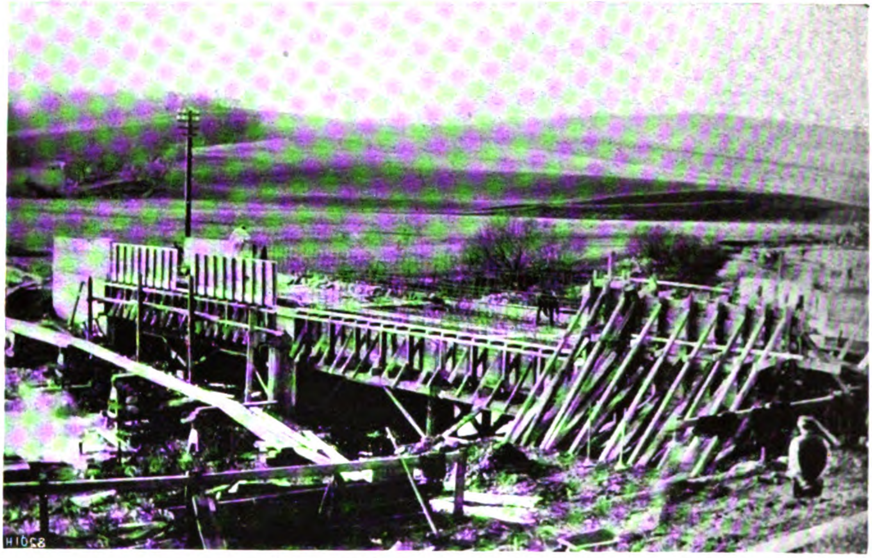


Mill in course of construction.

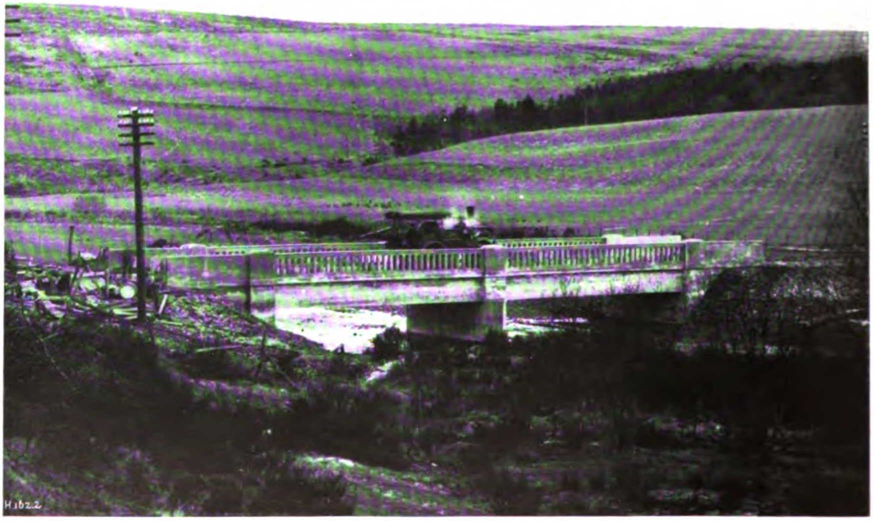
CONCRETE ON THE FARM.

The engine-house at the end of the building is 27 ft. by 12 ft., whilst the rest of the building is 52 ft. by 27 ft.

In addition to the four floors there is a tower on the building; the height of the tower to the top of the vane being 60 ft. About 5,000 blocks were used for this building.



View of Bridge in course of construction.



View of Finished Bridge.

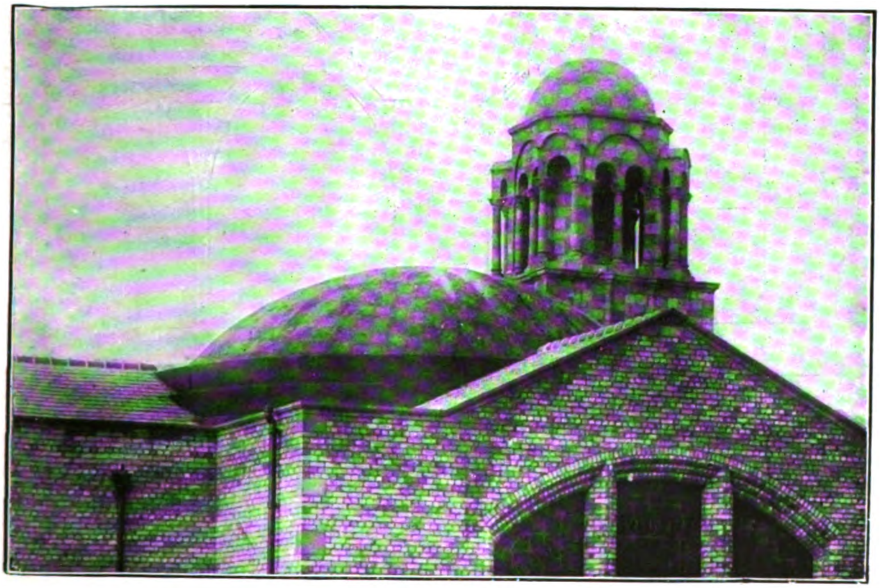
REINFORCED CONCRETE BRIDGE AT TIPPERTY, AUCHENBLAE.

We would add, in conclusion, that we are indebted to Messrs. E. W. Farrow and Son for our illustrations.

REINFORCED CONCRETE BRIDGE AT TIPPERTY, AUCHENBLAE, KINCARDINESHIRE.

THIS bridge has been erected by the Kincardineshire Road Board over a dangerous ford on the Bervie Water at Tipperty near Auchenblae. The bridge consists of two spans, each of 33 ft., and the width between the parapets is 19 ft. 6 in. The macadamised roadway is 16 ft. wide, has a gradient of 1 in 70 in the length of the bridge, and is carried by a slab 8 in. thick, supported on two centre beams 30 in. deep and 15 in. wide, and two side beams 48 in. deep by 12 in. wide. The slab is reinforced transversely by ½-in. rods at 5-in. centres, and longitudinally by ⅜-in. rods at 5-in. centres. The centre beams have each eight 1¼-in. rods in tension, and four 1-in. rods in compression; while the side beams have each six 1⅛-in. rods in tension and three 1⅛-in. rods in compression. The shearing reinforcement consists of stirrups of ⅜-in. rods in the centre beams, and of 5/16-in. rods in the side beams. The pierced parapet is 4½ in. thick and is reinforced by ⅝-in. vertical and horizontal rods. The whole of the reinforcement consists of plain steel rods.

The concrete for the reinforced work was composed of 186 lb. of cement to 4½ cu. ft. of sand and 6¾ cu. ft. of crushed granite; but the actual proportions were slightly varied in the course of the work so as to secure a dense mixture.



REINFORCED CONCRETE DOME TO NEW SYNAGOGUE, FALLOWFIELD, MANCHESTER.

The pier, abutment, and wing walls are of plain concrete composed of 186 lb. of cement to 4½ cu. ft. of sand and 9 cu. ft. of 1½-in. gravel or broken stone. The foundations were carried down to rock at a depth of 6 to 7 ft. below the bed of the river.

Gravel and sand for the plain concrete were obtained from the river bed at the site. For the reinforced work the aggregate consisted of ¾-in. to ⅜-in. crushed granite with sand partly from the river bed and partly from a pit in the vicinity.

The top surfaces of the slab and side beams were covered with a waterproof coating of asphalte ¾ in. thick. The roadway is laid with tar macadam, and the footpaths, formed by the tops of the side beams, are protected from the traffic by granite curbs.

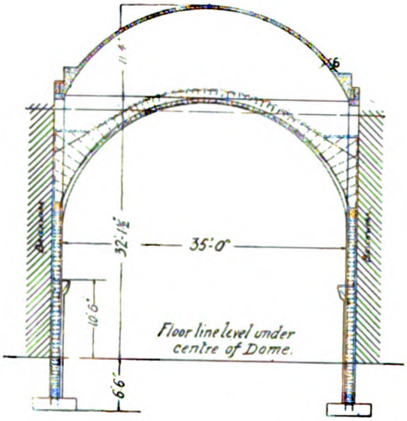
All external surfaces of the concrete were painted with cement grout.

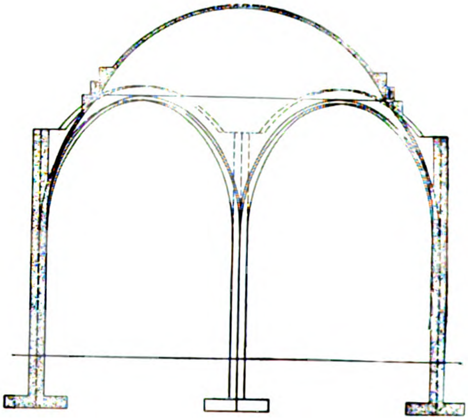
Four months after completion the bridge was tested by running on to each span three road rollers of an aggregate weight of 53 tons. Under this load the deflection at the centre of each span was rather less than 0·03 in. The beams were designed as simply supported on the pier and abutments.

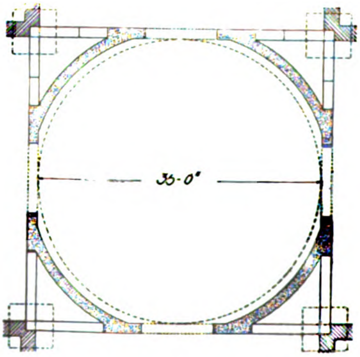
The engineer for the work was Mr. George Gregory, Jun., C.E., of Stonehaven, whilst the contractor for the work was Mr. William Tawse, Torry, Aberdeen. The cost of the bridge, including the tar macadam roadway and granite curbs, was about £700; in addition about £350 was spent in diverting roads and forming new approaches.

REINFORCED CONCRETE DOME FOR THE SOUTH MANCHESTER NEW SYNAGOGUE.

Reinforced concrete construction is admirably adapted to the design of the dome of this building. Two illustrations are given, one showing a section in detail, giving the general dimensions, and the other an outside view of the finished work. It will be seen that the dome is carried on four square concrete piers, which are continued to form four semi-circular arches, and on the square made by these four arches a circular concrete beam is formed, from which rises the shallow dome, giving very satisfactorily the desired effect of an Eastern place of worship.





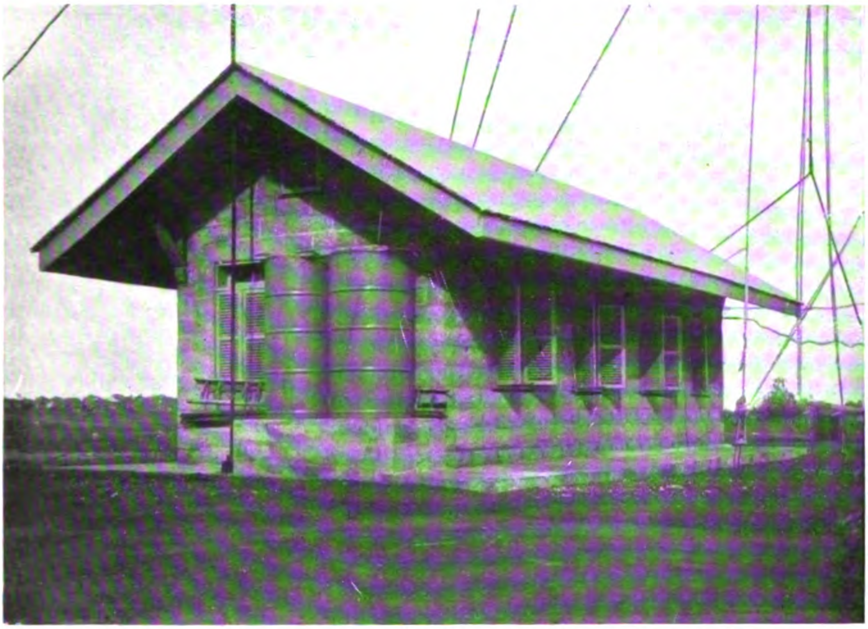


The architect was Mr. Jos. Sunlight, of Manchester.

The reinforced concrete construction was carried out by Messrs. Richard Johnson, Clapham, and Morris, of Lever Street, Manchester.

CONCRETE BLOCKS FOR MARCONI WIRELESS STATIONS.

THE accompanying illustration shows the Government Marconi Wireless Station and Machine House, at Accra, Gold Coast, West Africa. The building is one of a number erected by the Crown Agents for the Colonies Public Works Department in West Africa, and has been constructed in "Winget Blocks."



MARCONI WIRELESS STATION BUILT OF "WINGET" BLOCKS AT ACCRA, WEST AFRICA.

A NOVEL CONCRETE CIRCLE BLOCK CORN CRIB.

THE accompanying illustrations show a concrete circle block corn crib made with a special silo mould. It cures corn and heaps it to perfection, while the cost works out less than if built of lumber.

It has great capacity at small expense, and is rat-proof and fire-resisting, and it costs practically nothing in maintenance or repair. It will be seen that this circular structure is built of large flange blocks, easy to place and reinforce. The flange on block carries reinforcing wires and projects out from the wall to form water table over ventilated openings. Reinforced circle block walls have 20 per cent. ventilation, and the structure has a reinforced circle taper block self-supporting roof with ventilated cement block flue in centre of crib that exhausts in cupola at roof line.

The roof and walls are watertight. In the construction of this concrete circle block corn crib 14-ft. silo moulds were used to make the blocks. The walls are 2½ in. thick and the roof is 2 in. thick.

The corn crib has a foundation 8 in. wide by 7 in. deep, and is well reinforced. The floor is 2½ in. thick with woven reinforcement and extends over the foundation, so as to form part of it. The shallow foundation allows the structure and contents to come and go with the frost without damage.

The first row of blocks are settled in the green concrete of floors. On the top of the third row of blocks a rat proof extension projects out from the wall 3½ ins., and small wire mesh is placed on the inside of wall over openings below extension to exclude vermin. A galvanised iron door is hung on the gas pipe door frame which excludes the rats at this point, leaving no opening at which they can enter the crib.

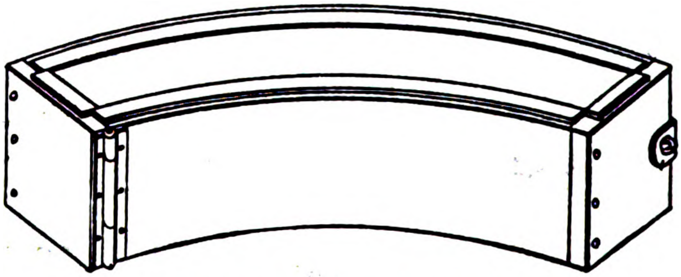


FIG. 1. FORM OF MOULD USED FOR CONCRETE CORN CRIB.

The roof is made of circle blocks 2 in. thick and tapered to suit the circle in which they are placed, and reinforced at the top to withstand the thrust from above. The cost of erecting this corn crib in America worked out at a total of $48.50; of this the roof is approximately one-third of the total cost. The weight of the roof is 4,100 lb.,

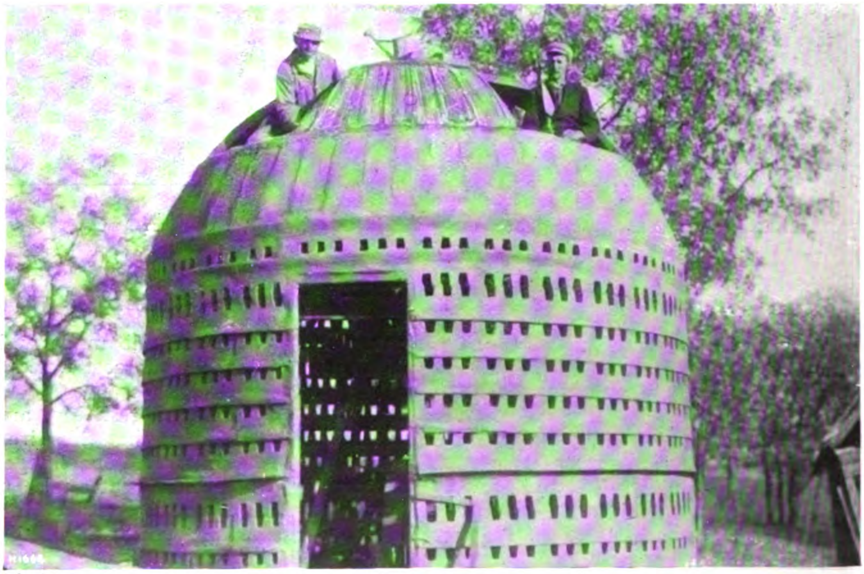


FIG. 2. VIEW OF REINFORCED CONCRETE CORN CRIB NEARLY COMPLETED.

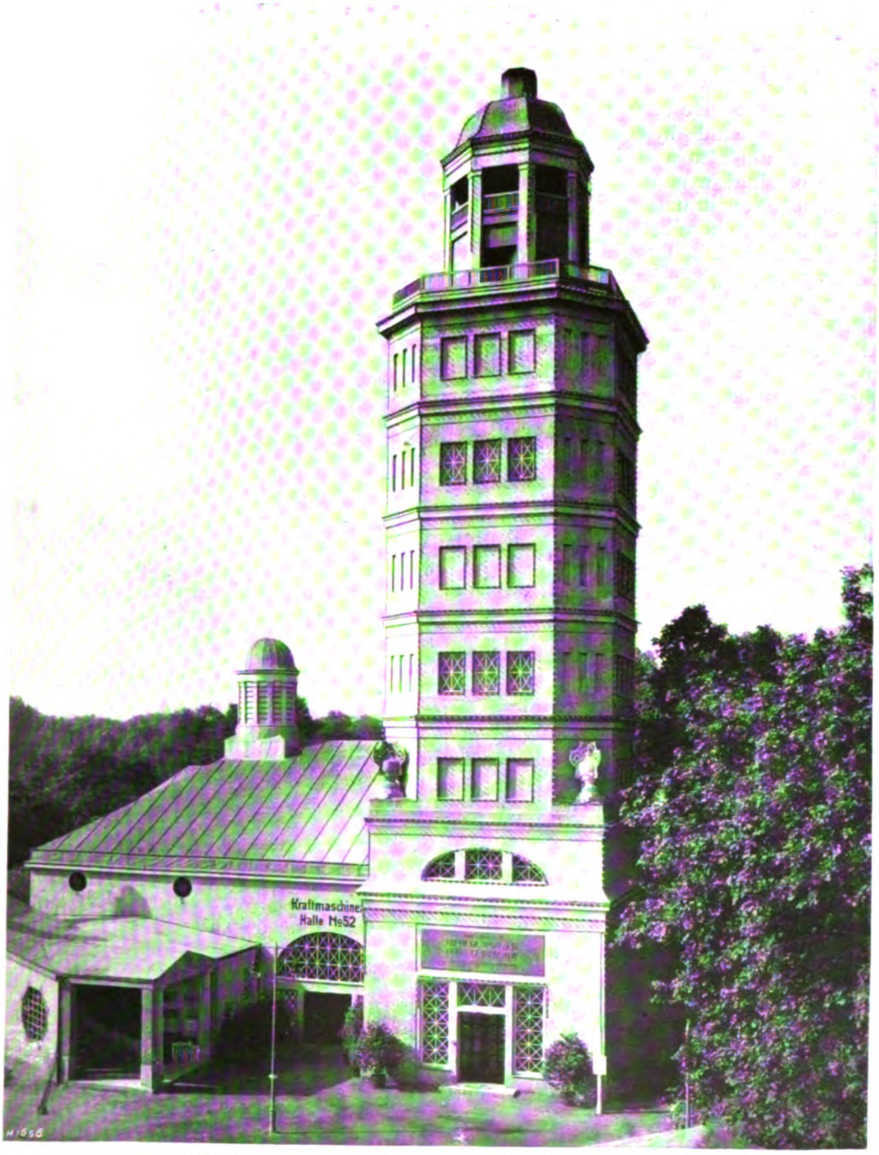
the walls weighing 6,900 lb., and the foundation and floor about 9,000 lb., while the total weight of the 14-ft. crib is about 10 tons.

The drawing in *Fig.* 1 shows the form of mould used in constructing this concrete corn crib as developed at Grand Rapids, Iowa.

A CONCRETE CHIMNEY AND SIGHT-SEEING TOWER AT DRESDEN.

THE German concrete chimney and sight-seeing tower at Dresden is seen in the accompanying photograph. This artistic concrete chimney measures 42 m. in height. The sight-seeing platform is located at a height of 32 m.

This tower was constructed by Messrs. A. Kühnscherf, Jun., formerly F. Wachsmuth, of Dresden.



A CONCRETE CHIMNEY AND SIGHT-SEEING TOWER AT DRESDEN.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

The Hydration of Portland Cement, Iron-Portland Cement, and Blast Furnace Slag. (*Die Hydratation von Portland cement, Eisen-portlandcement und Hochofenschlacken.*) By Dr. Ferdinand Blumenthal.

Cementverlag G.m.b H., Charlottenburg, 1914. Price, 1.75 Mark.

This pamphlet gives a general account of the chemistry and physics of the setting of cements, and also a series of very interesting original experiments, in which microscopical examination is combined with the use of chemical reagents. This part of the subject is illustrated by means of photo-micrographs. The following are the principal conclusions:—

Portland and iron-Portland cements yield the same products on hydration, namely: (*a*) hexagonal tables of tricalcium aluminate; (*b*) small needles of mono-calcium silicate; (c) gelatinous mono-calcium silicate; and (*d*) large hexagonal crystals of calcium hydroxide of relatively little importance for the process. The setting of cement is a process of crystallisation, the crystals of aluminate and silicate becoming interlocked, whilst hardening is due to the formation of a gelatinous mass, which unites the crystals in the same way as glue. This process continues as long as lime, silica and water are available. Iron oxide can take part in the setting, forming ferrous silicate and tricalcium ferrite. Blast-furnace slags which contain a sufficient excess of lime yield the same products.

The Influence of Moisture in the Air on the Volume of Cement Mortar. (*Einfluss der Wasserdampftension der Luft auf das Volumen des Cementmörtels.*) By Leopold Jesser.

Cementverlag G.m.b.H., Charlottenburg, 1913. Price, 1.50 Mark.

This pamphlet describes the influence of the absorption of water in the form of vapour by mortars of different richness on their volume. It is shown that the volume of a mortar increases with the moistness of the air and diminishes as it becomes drier. A mortar placed in air saturated with moisture undergoes a further, but relatively small, expansion when placed in water. These changes have been followed quantitatively. They are reversible, except for a change which takes place in mortars which have only hardened for a short time. These properties are dependent on those of the gelatinous mass which constitutes the greater part of the mortar. The thermal expansion of mortar also depends on its hygrometric condition. Some of these facts are of importance in connection with the behaviour of concrete dams and containers, one part of which is in contact with water and the other with air, and the subject deserves attention.

Handbook for Constructional Engineers in Reinforced Concrete. (*Aide-Mémoire de l'Ingénieur-Constructeur de Béton Armé.*) By Jean Braive.

Paris, 1914. H. Dunod & E. Pinat.

The compiler of this volume has set himself the task of compressing into less than 400 pages the essential formulæ and rules of the reinforced concrete engineer, together with a number of worked examples. Much of the material included is of a kind to be found in engineering pocket-books, such as tables of trigonometrical functions, lists of densities, etc., together with rules of arithmetic and mensuration. This section is followed by very brief notes on cement, methods of testing, and special systems of reinforced concrete construction. Eighty pages are then occupied by the French official regulations, which are given in full. This section, which should be found very convenient by workers in France, as a compact collection of official documents, is followed by a condensed treatise on the principles of computation of reinforced concrete structures. It is to be noted that Professor Mesnager, in his preface to the book, dissents from the principle adopted in the computation of resistance to shear, insisting that the method generally employed is incorrect. Many tables are given, but there is less resort to graphical methods of computation than is usual in other works on the subject. The general principles are next illustrated by worked examples of actual structures, including buildings, a chimney, water-tower, silos, bridges, and a sole-plate. The book, in which the attempt has been made to cover a somewhat excessive extent of ground, concludes with a useful vocabulary of technical terms in five languages.

The Handling of the Materials in Concrete and Reinforced Concrete Construction. (*Die Verarbeitung der Baustoffe im Beton- und Eisenbetonbau.*) **By Herr Riepert.**

Price, 35 Pf.

Concrete Pipes. (*Cementröhre*). **By Herr Riepert.**

Price, 35 Pf.

The Use of Cement-Lime or Trass Mortars in the Construction of Dams. (*Ueber die Verwendung von Cementkalk-oder Trassmörtel bei Talsperrenbauten.*)

Price, 30 Pf.

The Use of Concrete and Reinforced Concrete in River Engineering and Drainage Work. (*Die Verwendung von Beton- und Eisenbeton im Meliorationsbauwesen.*) **By Fritz Wichmann.**

Price, 1 Mark.

All published by Cementverlag, Charlottenburg.

These four pamphlets are examples of a type of monograph which is very familiar in Germany. Each deals, in considerable detail, with a single question in technical practice, and their low price and handy form make them very convenient for consultation in the course of actual practical work. The first, second, and fourth are issued in a series prepared by the Central Bureau for the Advancement of the German Portland Cement Industry; whilst the third, of a more controversial character, is issued by the Association of German Portland Cement Manufacturers.

The first pamphlet named above treats of such subjects as centering and shuttering, the raising of materials, concrete mixers, and mechanical devices for bending reinforcing rods and tying wires. It is abundantly illustrated, and the information is concisely expressed.

The monograph on concrete pipes gives a full account of the processes for the manufacture of these articles, varying in size from the 2-in. pipes used in draining agricultural land to large sewers. Reinforced concrete water-pipes and sewers are not included. In the smaller sizes, concrete pipes are intended to replace clay products (earthenware and stoneware), whilst in the larger sizes they take the place of brickwork.

The third publication on our list deals with a controversy of which little is heard in this country, but which has attracted much attention elsewhere—namely, the relative merits of mixtures of Portland cement with lime, and of hydraulic lime with pozzolanic material (trass) as components of mortar for masonry dams. The present contribution is written from the point of view of the Portland cement manufacturers, and largely takes the form of a reply to a recent manifesto issued by those interested in the sale of trass. A good deal of evidence is produced to show that considerable additions of either fat lime or hydraulic lime may be made to cement-sand mortars without injury to its employment in hydraulic engineering, and that such mixtures are often superior to those containing trass.

The last pamphlet deals with such subjects as canalisation and straightening of river channels, the construction of embankments and culverts, and irrigation work. Each section receives only very brief treatment, but there are many illustrative diagrams, and the little work should be found very suggestive by those who are concerned with the application of concrete and reinforced concrete to these purposes, for which the materials in question offer manifest advantages.

The Chadwick Public Lectures on Housing, 1913. By W. E. Riley, F.R.I.B.A., M.Inst.C.E., Sup. Architect of Metropolitan Buildings and Architect to the London County Council.

Published by the "Builder," Ltd., 4 Catherine Street, W.C. Price 6d.

These interesting lectures delivered by Mr. Riley last year have now been published in pamphlet form and are well worthy of the attention of all those who at present are specially studying this vast problem of housing. The lectures were broadly dealt with under the three headings: Unhealthy Areas, Unhealthy Houses and Cottage Estates. Whilst under the two former headings the author deals with the housing of the working classes in the confines of the London area, the last lecture is mainly devoted to the purchasing of estates by rural and other Councils on the outskirts of London and yet within easy reach of the Metropolis, with a view to erecting healthy dwellings.

It is impossible here to deal very fully with these lectures, and we can only refer our readers to the pamphlet, which, we would add, has been well illustrated.

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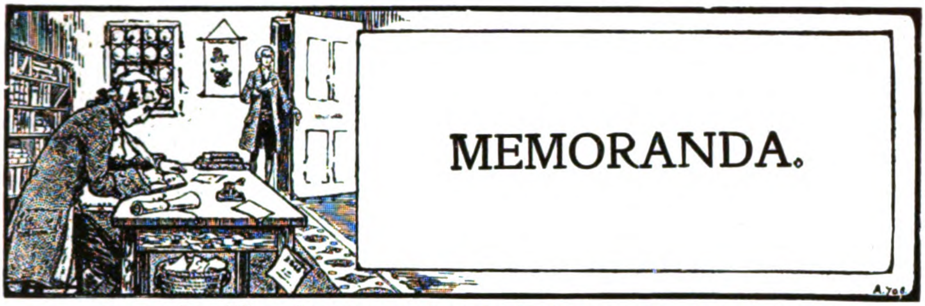

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Concrete Institute Annual Dinner.—The Fourth Annual Dinner of the Concrete Institute was held on May 28th, at the Connaught Rooms, the new President, Professor Henry Adams, M.Inst.C.E., being in the chair. Among the visitors present were Sir John A. Cockburn, K.C.M.G., and Mr. Ellis Marsland (President of the District Surveyors' Association).

Of the five Vice-Presidents, Mr. H. D. Searles-Wood, F.R.I.B.A., attended, and the members of the Council present comprised Sir Henry Tanner, C.B., Mr. Bamber, F.C.S., Mr. Butler, A.M.Inst.C.E., Mr. E. Fiander Etchells, F.Phys.Soc., Mr. J. Ernest Franck, A.R.I.B.A., Mr. Osborn C. Hills, F.R.I.B.A., Mr. W. G. Perkins, Mr. A. Alban H. Scott, M.S.A., Mr. E. P. Wells, J.P., Mr. G. C. Workman, M.S.E., and Mr. M. E. Yeatman, M.A.

The following is a summary of the proceedings, in which we have curtailed certain portions of the President's remarks which appear to have given umbrage to a number of the members and visitors present and did not seem to be quite in place at a gathering of this description, or to accord with the spirit of compromise that appeared to have some chance of inauguration at the General Meeting that preceded the Dinner.

The President, in proposing the health of The King, described His Majesty as "a concrete example of everything that was noble." The Queen, Queen Alexandra, the Prince of Wales and the other members of the Royal Family he looked upon as "a reinforcement of the highest value to the nation."

Mr. Ellis Marsland (President of the District Surveyors' Association) proposed the toast of the evening, "The Concrete Institute." He had watched the progress of the Institute from its inception to the present time with very much interest, and his keynote that night was one of congratulation, first of all on account of its membership, secondly on account of its objects, and thirdly on account of its work. In the early days of reinforced concrete construction, one was left to the tender mercies of various patentees and rival firms who magnified their own systems to their rivals' disadvantage, but the Institute had changed all that. It had evolved order out of chaos, and had standardised and regulated the whole system of construction so as to make it practicable and workable. He did not mean to imply that there were more failures in the reinforced concrete form of construction than in any other—in fact, his own opinion was that there were fewer, but still at the same time the public wanted reassuring on that point, and it was the duty of the Institute to go into the question, ascertain the cause of these failures, and bring about a remedy. He expressed the hope, in the words of the Prayer Book, that "unity, peace and concord might prevail" so that the Institute might have an uninterrupted and successful career of usefulness and prosperity. (Cheers.)

The President, in reply, said that for an Institute founded only so recently it had achieved a notable result in obtaining over 1,000 members. That was a very good evidence that it fulfilled a want, and had a distinct mission to perform. It had many interests, and by means of its Committees had already done a considerable amount of useful and practical work. It came in on a flood tide, and its immediate success was almost phenomenal. The meetings were crowded, and the copies of the papers were eagerly sought after. Then, unfortunately, there was an ebb; the attendance fell off because it was found that in concrete alone there was not sufficient scope. (Question.) The Council, in considering the matter, came to the conclusion that some development was wanted, and he thought they decided to admit papers on a constructional steel work where no concrete was employed or only employed in a secondary manner. The result was that the interest in the meetings revived and the attendance went up again with a bound. Naturally, the Council then fully considered the whole position, and they came to the conclusion that some amplification of the title was desirable. They added the sub-title, "An Institute for Structural Engineers, Architects, etc." Although this alteration was welcomed by many it did not give universal satisfaction. Cement makers, chemists and contractors felt that they were being left out in the cold. One of the great advantages they had enjoyed hitherto had been the meeting together on mutual terms of engineers, architects, cement chemists and contractors, and in order that they might make solid progress it was necessary that all these varied interests should combine together into one harmonious whole. (Cheers.)

Structural engineering was the one term that best expressed the variety of work of which the Institute took cognisance, but that did not mean constructional steel work alone, as some seemed to think: it included all varieties of building in all materials where stability was the chief aim. It appeared to him that there was scope at the present time in all large buildings for the collaboration of the architect and the structural engineer. As to the burning question of the position of the so-called specialist, specialist firms were simply contractors, but their experts were structural engineers of the highest class, and were the mainstay of the Concrete Institute. (Cheers.)

The Council had elaborated a scheme of examinations which he hoped by the autumn would be in full working order. The intention was that the graduates and associate members should be able to obtain certificates testifying to their knowledge of the various branches that came under the domain of the structural engineer and the architect. At present the examinations would be entirely voluntary, but there was no doubt that the time might come when the question of making them compulsory would be considered.

The Council would gladly welcome suggestions from any source that would tend to put the Concrete Institute on a firmer basis and make it more useful to the members generally.

Mr. H. D. Searles-Wood, F.R.I.B.A. (Vice-President, C.I.), proposed "The Visitors," and thought they might take it that the Royal and learned Societies which these gentlemen so well represented showed, by their presence that night, that they were in amity and concord with the Concrete Institute, a very Benjamin among the brethren in respect of age but a lusty youth which they welcomed into their family circle.

Sir John A. Cockburn, K.C.M.G. (late Premier for South Australia), in acknowledging the toast, confessed that in this matter he was a quack. (Laughter.) He began his practice of quackery in reinforced concrete in the year 1880, and he was looking forward to the Whitsuntide holidays to put in the biggest job in a reinforced concrete roof he had ever undertaken—an unsupported span of 20 ft. by 12 ft. with nothing but reinforcement in the concrete. (Renewed laughter.) As a quack, he differed from the quacks in most professions in having a profound reverence and admiration for the legitimate practitioners, and therefore he was proud to be among the guests, and especially proud because he recognised that this was a live Society and not that dull monotony and uniformity of opinion which was death to any institution. In other words, they had the essence of reinforced concrete in the Society, they had the thrust of divergent opinions and the tie of association binding them all together

Mr. E. Fiander Etchells, F.Phys.Soc., proposed the health of the President in a very amusing speech, and the President acknowledged the compliment.

Professor E. R. Matthews.—We tender our congratulations to Mr. Ernest R. Matthews, A.M.Inst.C.E., who has recently been appointed to the Chadwick Chair of Municipal Engineering at the London University. Mr. Matthews, who has been Borough Engineer of Bridlington for nearly sixteen years, is well known to the readers of this Journal by the interesting articles he contributes to our pages from time to time.

Rosyth Naval Base.—In connection with the work which is being carried out at Rosyth a considerable amount of concrete work is being done. The floors of two of the large graving docks are of concrete some 20 ft. thick, this extreme thickness being due to the fact that the rock upon which they are built is none too strong.

About the hardest task with which the contractors have been faced, says the *Naval and Military Record*, is the erection of the huge sea-wall which is being built round the tidal basin, the difficulties being due chiefly to the enormous size of the materials which are being used. Work is proceeding on the monolith system, huge concrete monoliths, 40 ft. square, being sunk to the permanent foundations, a work which is naturally laborious and slow. However, the most difficult part of the erection of the seawall has been carried out, and rapid progress is being made with the remainder. A large number of concrete mixers are in use, and something like 10,000 cu. yd. of reinforced concrete are used each week.

Hospital Architecture and Construction.—In an article on "Sanatoria Buildings," by Mr. A. Alban Scott, recently published in the *Hospital*, Mr. Scott gives some particulars of plans completed by him of a sanatorium for 100 beds. In dealing with the constructional details the author shows to what an extent concrete could be used with advantage for buildings of this kind. We give the following extract from the article:—"The construction is as follows:—

Floors.—The ground to be excavated to the necessary depths and made up to the required levels. Not less than 6 in. Portland cement concrete to be placed under all buildings. These to be prepared for and paved with jointless paving, as used in many institutions, formed of asbestos, etc., finished in either grey, buff, green, or red colour.

Walls.—The walls to be rough-cast or other cement coat finish on the outside, and would be constructed of panels built between the reinforced concrete structural work in the form of columns and beams, each panel being formed of 3-in. brickwork on the outside with a cavity of 2 in., and a panel on the inside filled in with concrete walls 2 in. thick, the inside walling plastered with two coats, the latter being finished smooth ready to receive decoration either in the form of distemper or, when the plastering is quite dry, paint and enamel.

Roofs.—These to be formed of reinforced concrete with special asphalte covering on the outside, the inside to be plastered as described for the walling.

Reinforced Concrete Footbridge at Hitchin.—The footbridge which spans the river Hiz, at Charlton, Hitchin, is to be rebuilt in reinforced concrete with an iron hand railing. The cost of maintaining the bridge is shared by the Urban District Council of Hitchin and by the Hertfordshire County Council. These two authorities have decided to share the cost of erecting the bridge.

Dundee Craig Pier.—In connection with the extension work which has been carried out by the Dundee Harbour Board to the Craig Pier, two concrete walls have been constructed, each 8 ft. 7 in. thick and about 10 ft. high.

Administrative Offices for the Port of Para.—In our issue last month (pp. 332-338) we published an article on these offices. In the course of the article it was stated that the internal and external walls were built of concrete blocks. We should like to add that the blocks used for the external and internal walls were "Winget" blocks, made on "Winget" machines.

Concrete Specifications in Detroit Building Code.—The Detroit City Council has recently amended that part of its building code relating to concrete building and block construction. Some of the provisions are given below.

For columns reinforced with longitudinal bars tied at intervals not greater than twelve times the least diameter of the bars the safe load shall be computed as follows:—

Safe load (in pounds) $= 550\ (A_c + 12A_s)$, where A_c = net cross-section of column in square inches, and A_s = cross-section of longitudinal reinforcement in square inches.

For columns reinforced with longitudinal steel and with spirally wound hooping the safe load shall be computed as follows:—

Safe load (in pounds) $= 650\ [A_c + 12\ (A_s + 2{\cdot}4\ A_h)]$ where A_c = net cross-section of concrete enclosed in hooping, A_s = net cross-section of longitudinal reinforcement (not to exceed 8 per cent. of A_c) and $A_h = 3{\cdot}14\ d\ a/p$, where d and p = respectively diameter and pitch of hoop in inches and a = cross-sectional area in square inches of wire or rod forming hoop, provided that A_h shall not be less than 0·5 per cent. nor more than 1·5 per cent. of A_c, and that p shall not be more than one-tenth the diameter of hoop nor more than 3 in.

Flat Slab Floors.—Girderless flat-slab floors reinforced in either two or four directions and supported by enlarged column capitals may be constructed according to the following principles:—It is assumed that w = total dead and live load per square foot; l, length of one side of panel if square or larger dimension, measured from centre to centre of columns, if rectangular; B, shorter dimension of rectangular panel measured from centre to centre of columns; L, side of square having same diagonal as $B\ l$ (in a square panel it equals $\overline{l}$) D, diameter of column capital at a point where it is at least 1½ in. thick, and K, bending-moment co-efficient having the values hereinafter defined. Then D must not be less than 0·225 L and the sides of the column capital must not slope at an angle with the perpendicular of more than 45 deg., provided that

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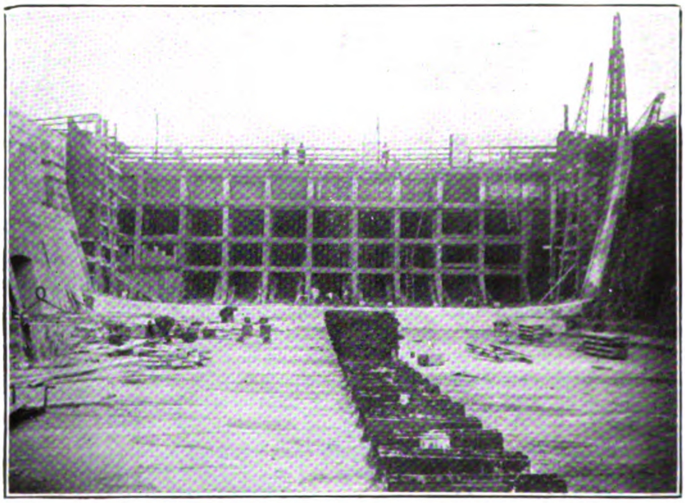

Illustration shows dam at entrance to Western Dry Dock, Royal Albert Docks. The Piles were our 15 × 5 in. Section in 46 ft. Lengths, and had to withstand a head of water of 35 ft.

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if the slab is increased in thickness around the capital, the diameter of the capital may be reduced by one and one-half times the thickness of such drop. Also l must not be more than 1·25 B.

For slabs reinforced in four directions, the steel in the centre of the panels shall be designed to resist a bending moment of $w\,l^3/25$ for interior and $w\,l^2 22$ for exterior panels. The steel so determined shall be divided equally among two diagonal and two cross bands for square panels, and in the case of rectangular panels one-half of this steel shall be equally divided between the diagonal bands and the remainder between the cross bands in proportion to the cubes of their lengths.

The negative bending moment in 180 deg. around the column capital, that is the negative moment resisted by two diagonal and two cross bands at the supports, shall be taken as $wl^3/15$.

To compute the concrete stress at the column capital a negative bending moment of $wl^3/25$ shall be assumed to be resisted by a band of concrete not wider than D plus six times the slab thickness, nor wider than the sunken panel or drop if such is used, nor wider than 0·4l.

Reinforced in Two Directions Only.- For slabs reinforced in two directions only the bending moments in each direction shall be calculated by dividing the slab into eight equal strips starting from the centre line of two columns. Each strip shall be regarded as a continuous beam having a positive bending moment at the centre and a negative bending moment at the line of supports. The bending moment at each of these points shall be $wl^3/8K$ for square panels and $wl^2 B/8K$ in the direction of l and $wB^2 l/8K$ in the direction of B for rectangular panels. K shall be for interior panels as follows, starting at the centre line of columns :—

	At line of supports.	At **centre.**
First strip	— 13	+ 26
Second strip	— 19	+ 38
Third and fourth strips each	- 58	+ 58

For exterior panels these values are to be decreased 20 per cent. Compressive stresses in concrete are to be calculated by assuming that the entire width of each strip resists the bending moment assigned to it.

If desired, that portion of the slab lying between column capitals may be regarded as a continuous girder and the central portion of the plate as a slab reinforced in two ways and supported on all four sides.

That portion considered as a girder shall not be wider than the column capital plus six times the thickness of the slab nor wider than 0·5 l.

The negative bending moment at the support and the positive bending moment at the centre shall each be taken as $wls^2/24$ where s is clear span in direction of girder and l is distance between column centres at right angles to girder.

The remainder of the slab shall be known as the inclosed panel and shall be bounded by lines parallel to lines of centre of columns and at a distance from edge of column capitals not greater than two and one-half times the thickness of the slab.

The bending moment at each edge of the inclosed panel shall be taken as $w\,p^3/24$ and at the centre as $w\,p^3/36$ in each direction where p is the side of the square for square panels and is the side of an equivalent square for rectangular panels.

No flat slab shall have a thickness at the centre of less than $l/32$ for floors, nor less than $l/35$ for roofs.

When the slab near the column capital is increased in thickness so as to form a sunken (or raised) panel or drop the dimensions of this drop shall be not less than 0·375 times the panel length in the same direction.

Ten Concrete Road Essentials.—Mr. Ernest McCullough, Consulting Engineer, of Chicago, in a Paper presented at a recent meeting of the Illinois Society of Engineers and Surveyors, gave the following ten essentials for concrete road construction, viz. : (1) Intelligent supervision; (2) Careful selection of materials; (3) Proper proportioning; (4) Proper mixing, using batch mixers only; (5) Moderate use of water; (6) Avoidance of a mix leaner than 1 : 2 : 3; (7) Use of reinforcing on wide roads and over filled spots; (8) Use of combination metal and fibre expansion joint fillers at intervals of about 25 ft. across the road; (9) Avoidance of longitudinal joints; and (10) a visit to some concrete road under construction before attempting to construct one.

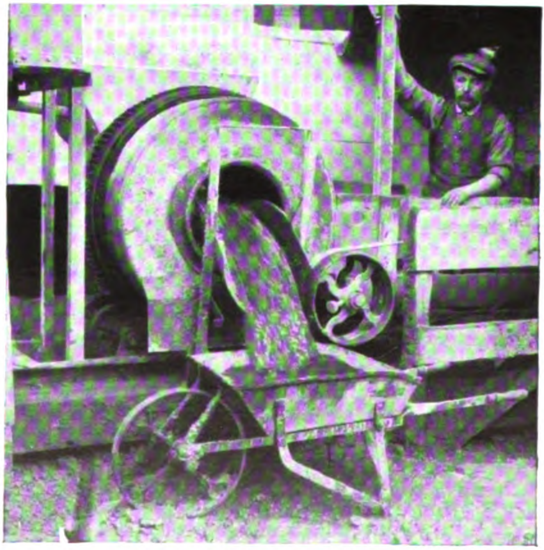
The Late Mr. W. G. Kirkaldy, A.M.Inst.C.E.—We have to record with deep regret the death of Mr. Kirkaldy, who rendered so much service in the investigation of concrete and reinforced concrete by his testing work. He was also a member of the Sub-Committee of the International Association for the Testing of Materials, in charge of investigations into concrete and reinforced concrete, and he was the Chairman of the Tests Standing Committee of the Concrete Institute. We regret that owing to an oversight this note did not appear in our May number.

TRADE NOTICES.

Appleby and Co.—Messrs. Appleby and Co. advise us that they have recently moved to larger premises, and that their new address is 12, The Broadway, Westminster, S.W. They have also issued a small leaflet with illustrations of the various engineering plant put on the market by them, and we would here draw special attention to their pile drivers and concrete mixers. Detailed pamphlets will be sent to those interested on application to Messrs. Appleby at the above-mentioned address.

"Poilite" Asbestos Cement Building Sheets.—These sheets are made for inside and outside use. It is claimed for them that they are fire-resisting, sound proof, and non-absorbent. Regarding the first named quality, it was reported recently in the *Architect* that the sheets rendered some service at a fire which broke out at a confectionery works at Blyth. The works consisted of two buildings, an old and a new portion. The old portion was completely gutted, but in the new building all the ceilings had been formed by nailing "Poilite" sheets, 5-32 in. thick, direct to the wood joists, and by the presence of these sheets, it is stated in the *Architect,* it was possible to limit the area of the fire in the new building to the ground floor.

"Poilite" can be used for lining walls, partitions, ceilings, etc. It is claimed that they do not warp and will lie quite flat. They can be veneered, varnished, or primed and painted after fixing. No special tools are required for cutting them, and they can be fixed with nails or brads. The sheets are equally useful in hospital or school, hall or bungalow. They are made in various sizes, from 4 ft. by 4 ft. by 5-32 in., to 12 ft. by 4 ft. by $\frac{3}{16}$ in. Full particulars will be furnished on enquiry to Messrs. Bell's United Asbestos Co., Ltd., Southwark Street, S.E., who are the sole manufacturers of "Poilite" sheets.



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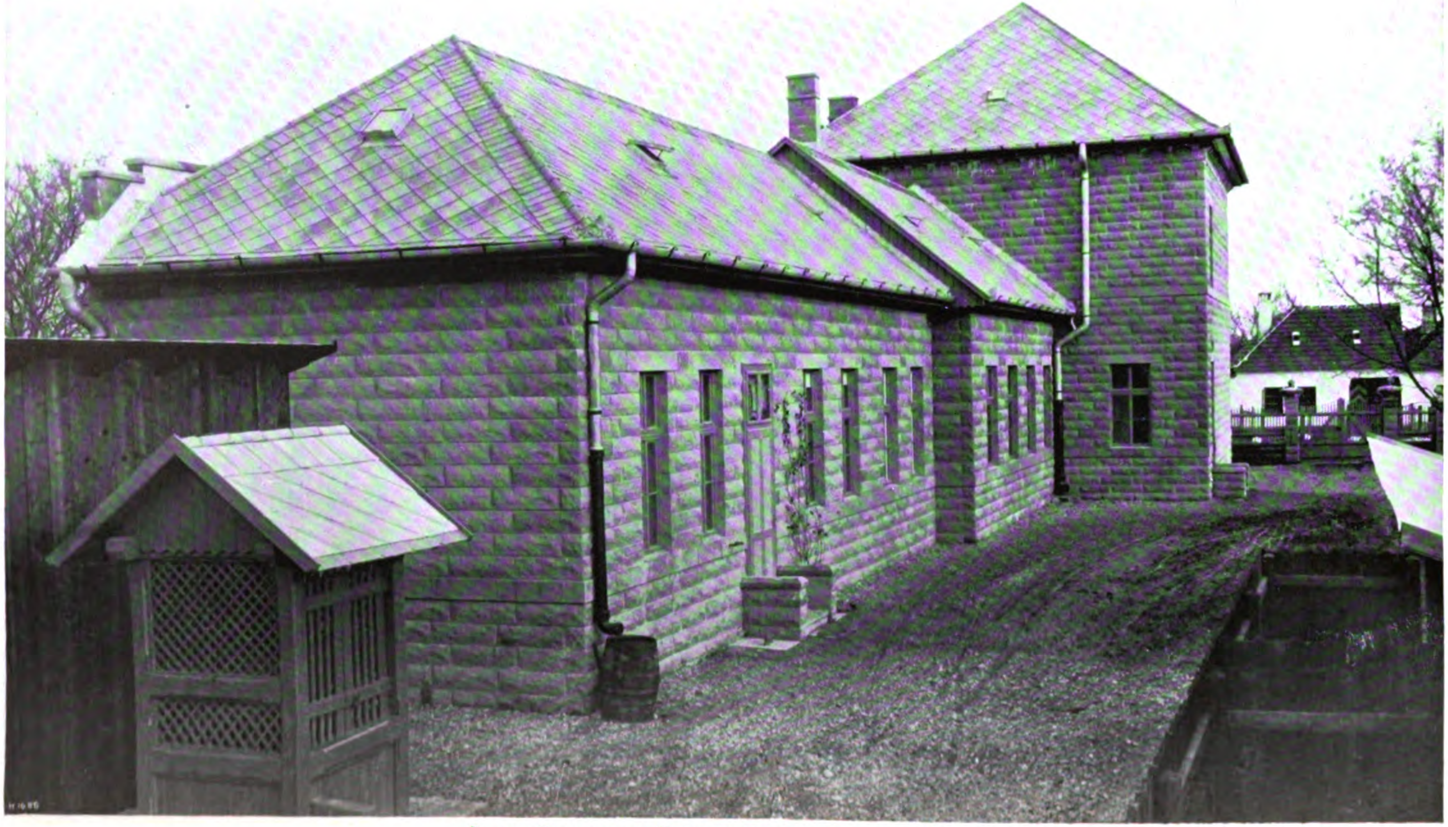


School Buildings in Hungary built of Concrete Blocks
(*For description see p.* 494.)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume IX. No. 7. LONDON, JULY, 1914.

EDITORIAL NOTES.

OUR CONCRETE COTTAGE COMPETITION.

It is with much pleasure that we are able to announce the result of the Concrete Cottage Competition organised by this Journal, and the following are the successful competitors:—

First Prize: One Hundred Guineas.

ERNEST S. THOMPSON, Architect, 5, Victoria Street, Westminster, London, S.W.

Second Prize: Fifty Guineas.

CHAS. BULMAN PEARSON, Licentiate R.I.B.A., 109, High Road, Chiswick, London, W.

Third Prize: Twenty-Five Guineas.

HAROLD G. HOLT, A.R.I.B.A., 11, Probyn Road, Wallasey, Cheshire.

Fourth and Fifth Prizes: Ten Guineas each.

LEONARD G. HANNAFORD, 42, Rock Park, Rock Ferry, Cheshire.
M. CROSNIER, 20, Brechin Place, South Kensington, London, S.W.

At the same time, having regard to the large number of competition drawings sent in, the journal also has pleasure in announcing that, apart from the awards under the competition conditions, two consolation prizes of Five Guineas each have been awarded to:—

J. COCKER and T. HILL, A.A.R.I.B.A., 20, Station Buildings, Stamford New Road, Altrincham.

E. W. STUBBS, A.R.I.B.A., Grayshott, Marlborough Road, South Croydon.

The whole of the drawings that have been sent in for this competition will be exhibited in the Lecture Hall of the Surveyors' Institution, 12, Great George Street, Westminster, S.W., from July 6th to July 11th inclusive (11 a.m. to 6 p.m. daily).

We present on the following pages, firstly, the assessors' report; secondly, a commentary on the competition; thirdly, the illustrations of the five designs to which the assessors have accorded the five prizes; and, fourthly, the specifications that have accompanied the designs.

THE ASSESSORS' REPORT.

THE assessors express their satisfaction with the number and general character of the designs, which show the interest taken in the simple, but important, economic problem of cheap cottage building.

The special character of the competition is its demand for a design suitable for execution mainly in some form of concrete, instead of wholly in the usual materials of brick, tile, slate, stone, or carpentry.

This requirement necessarily affects the planning by imposing great simplicity of external form. It also tends to exclude or render superfluous the picturesque breaking up of the elevations.

The architectural problem is, therefore, not so easy as it is simple, precedents not lying at hand in the countryside or in local county traditions.

The conditions of concrete construction and design being granted, the main problem is the provision of the best accommodation possible for the fixed limit of expense.

The conditions explain that the sum of £125 is exclusive of builder's profit, sanitary fittings (which would be of stock prices), fences, land drainage, etc. The cost of the drains was expressly excluded, so that comparison could not hastily be made with the cost of completed cottages, which may or may not have been connected with sewers or have involved expensive drainage. The sum of £125 was settled for the purposes of the competition, and must not be taken as the total cost of completing any of the cottages.

The arrangement of the plan within these limits is the remaining but preeminent condition—domestic economy and the requirements of three bedrooms for the family with the living room and necessary adjuncts ruling the decision, and leaving no space to be wasted.

The Assessors award the first prize to Design No. 206, the second prize to Design No. 75, the third prize to Design No. 193, the fourth prize to Design No. 205, and the fifth prize to Design No. 56.

(Signed) MAX CLARKE,
BERESFORD PITE,
EDWIN O. SACHS.

COMMENTARY ON THE £125 CONCRETE COTTAGE COMPETITION.

THE result of this competition is decidedly interesting, both from an architectural point of view and as helping to solve the economic problem as to the best means of housing the rural population who are in receipt of a very small weekly wage, and consequently unable to pay even a reasonable amount of rent for a cottage. Much time and thought has been expended in attempts to decide how much accommodation shall be provided in order to decently house a growing and increasing family, so that there may not be overcrowding.

Naturally some happy medium must be arrived at which seems to have been met by the conditions of this competition. It provides for a living room or kitchen and sleeping accommodation for father, mother and four children, which may be interpreted as a kitchen, three bedrooms and a scullery or wash-house, with places for food, fuel and sanitary accommodation. In country districts the provision of sink, w.c., and the drainage thereto, if water-borne sewage is contemplated, usually involves an outlay out of all proportion to the cost of the main building, and the question as to whether a detached earth closet would not meet all the requirements of health and sanitation is one which merits the careful consideration of those who are interested in the housing problem, so that some broad principle should be agreed upon. This point has not received the consideration it deserves.

Another matter which is of great importance in the housing problem is the area and the height of the rooms. It is one thing for rooms in town dwellings to be at least 8 ft. 6 ins. high, but it is quite another matter in the country where all the doors and windows can be left open, and where probably the occupants spend the greater portion of their life out of doors. In the latter case it might reasonably be presumed that a less height than 8 ft. 6 ins. would be sufficient, without any detriment to the health of the occupants.

All these questions are of vital importance in the production of an economical design. The grouping of a number of cottages no doubt tends to economy, but in cases such as the present problem; cost is the first consideration, and groups, instead of isolated buildings, would appear to be one step which should be agreed upon as giving the best return for a fixed outlay.

The public generally, and some designers, do not seem to differentiate between a cottage for the labouring classes and a "week-end" cottage. Money is wasted on the little extravagancies of the latter which are quite out of place in the former, as the less weekly rent a cottage can be let for, the greater the advantage conferred upon the occupier. Questions such as these led the proprietors of "Concrete and Constructional Engineering" to promote this competition and to offer five prizes the aggregate value of which amounts to the very handsome sum of £204 15s., the first prize being one hundred guineas, the second fifty guineas, the third twenty-five guineas, and two prizes of ten guineas each.

A large number of drawings, 249 sets in all, were sent in, amongst which nearly every type of cottage was represented in some form or another.

In most parts of the country the materials for the aggregate of concrete can be obtained in some form, and if the material is dealt with in a proper manner the construction can be made efficient and lasting with a minimum of cost for upkeep, an important item from the owner's point of view.

The assessors therefore decided that those designs in which concrete was largely used complied to the greatest extent with the requirements of the conditions, and as a result selected design No. 206 as the most suitable to which to award the first prize of one hundred guineas. It is an isolated one-storey cottage, in which concrete is used throughout, having an excellent plan with a central living room 185 ft. in area, and three bedrooms, being 102 ft., 106 ft. and 125 ft. in area respectively. There is a scullery 56 ft. in area and food store off the scullery, and a w.c. and fuel store, both entered from the outside. The rooms are 8 ft. in height, and there is no waste space whatever in the plan, the whole being conveniently arranged with a view to economy of labour in carrying out the domestic duties of the housewife. The windows are so placed that each room will get sun during some hours of the day. The flat roof adopted, while being somewhat novel in design, would be a pleasing feature in the scheme, and is skilfully treated so that only one rainwater pipe is required. The author is to be congratulated on his clever treatment of the problem, and it is to be hoped the design will be carried out at an early date. The total cube is 8,130 ft., and the estimate cost is £125 10s. This sum, according to the conditions, does not include drainage, water supply, sanitary equipment or plumbing, and the work to be carried out by an owner buying his own materials and employing direct labour.

The second premium of fifty guineas goes to design No. 75, a one-storey pair of cottages. In this concrete is also used throughout for the construction. There is a central living room 154 ft. in area and three bedrooms, having areas of 126 ft., 68½ ft. and 68½ ft. respectively, the scullery is 44 ft. in area, there is a food store entered from the scullery, and a w.c. and copper both outside. The rooms are 9 ft. high to the collar of the roof, and about 7 ft. 6 in. to the junction of the sloping roof with the wall face.

The total cube for the two cottages is 14,362 ft., and the estimated cost is £249 6s. 10d. at 4⅙d. All the windows face east or west, there being none at the ends. Any number of cottages could be built in a row at a minimum of cost. The roofs are sloping, covered with some form of cement tiles, and the small projecting porches constitute a pleasing break in the long line of the frontage to the west.

Design No. 193 takes the third place, with a premium of 25 guineas, a pair of two-storey cottages, concrete being the material used. In this design there is a central living room with a scullery and one bedroom on the ground level, and two bedrooms on the first floor.

The living room is 151 ft. in area, and the three bedrooms 169 ft., 142 ft., and 71 ft. in area respectively; the scullery is 73 ft. in area; a food store is entered from the scullery, and a w.c. and fuel store both outside the house. The rooms on the ground floor are 8 ft. 3 in. high, and the two bedrooms on the first floor are 8 ft. 3 in. average high. The exterior is treated with projecting bands of concrete and a rather expensive cornice for this class of house, which might well be simplified in execution. The pitch of the concrete roof is very flat and shows very slightly above the parapet; " Hyrib " is used in the reinforcement of the concrete, in combination with a limited use of bars. The design is suitable for building in blocks of four in a row; a black tarred skirting protects the lower portion of the external walls from wet and damp, and would be effective in execution.

The total cube of the two is 14,718 ft., and the estimated cost is £245 6s. at 4d. per cu. ft.

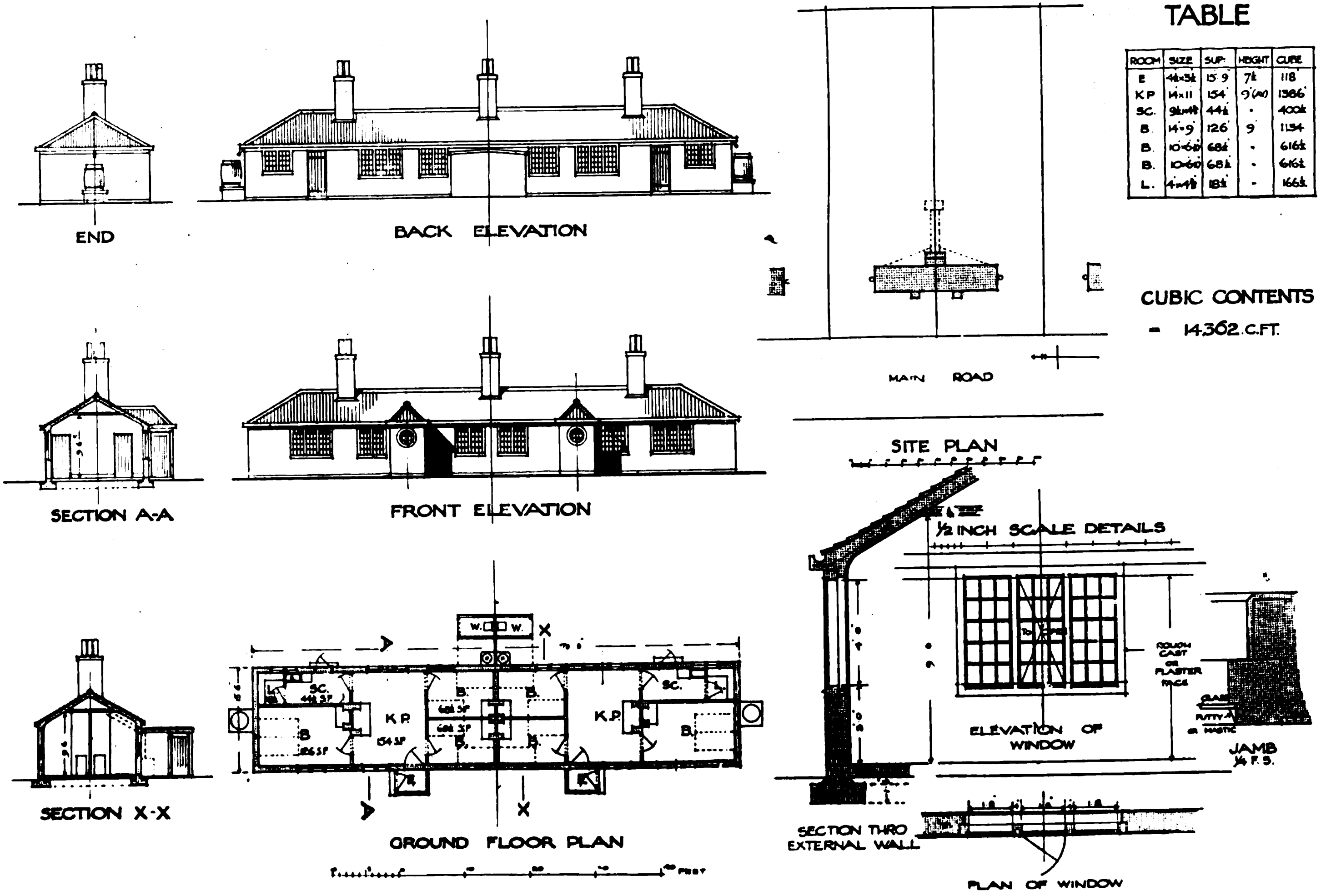
One of the prizes of ten guineas goes to design No. 205, which is bracketted with No. 56. No. 205 is the only one of the premiated designs in which an approximately square plan is adopted for a block of two cottages, the living room being in front, with the scullery, fuel larder, and w.c. at the rear, with three bedrooms on the first floor. The living room is 156 ft. in area, the scullery 61 ft. in area, and the three bedrooms 135 ft., 80 ft., and 50 ft. in area respectively. The kitchen and scullery are 8 ft. 3 in. in height, and the bedrooms on the first floor are 8 ft. in height. A good feature in the bedrooms is that the windows are high up and close to the ceiling, so leaving no space for stagnant air above the window heads. The design is simple, depending on raised bands and panels for effect, which give the exterior a somewhat monumental character. The roof is of concrete hipped all round, and there is a suspended ceiling which may be considered one of the items of luxury in the design; the fireplaces are cleverly arranged in the centre of the block, and the flues carried up in one stack for the pair of cottages.

The design is suitable for erecting in pairs, not in rows. The total cube for a pair is 14,555 ft., and the estimated cost £242 12s. for the two at 4d. per cu. ft. Design No. 56 is bracketted with No. 205, both receiving prizes of ten guineas.

This scheme shows a block of two cottages with two bedrooms to each cottage on the first floor, which is entirely in a mansard roof, constructed of concrete. The balconies to the first-floor windows might well be omitted as being both unnecessary and unsuitable in houses of this class. If a part of the money saved on the omission of these was to be spent on a raised block to support the water butts it would be appreciated by the occupier. A water butt is a convenience, and much more so when it is placed so that a bucket can be put under the wooden tap in general use. The same remark applies to Nos. 193 and 205.

All these competing gentlemen should recollect in future that water butts are for use more than for ornament and cease to be a pleasing feature in the design when they become old, in want of paint, and probably with a fungoid growth as an architectural dressing.

CONCRETE COTTAGE COMPETITION



TABLE

ROOM	SIZE	SUP.	HEIGHT	CUBE
E	4½×3½	15 9	7½	118
K.P	14×11	154	9' (AV)	1386
SC.	9½×4⅝	44½	·	400½
B.	14×9	126	9	1134
B.	10·6×6·6	68¼	·	616½
B.	10·6×6·6	68¼	·	616½
L.	4×4⅝	18½	·	166½

CUBIC CONTENTS

= 14,362 C.FT.

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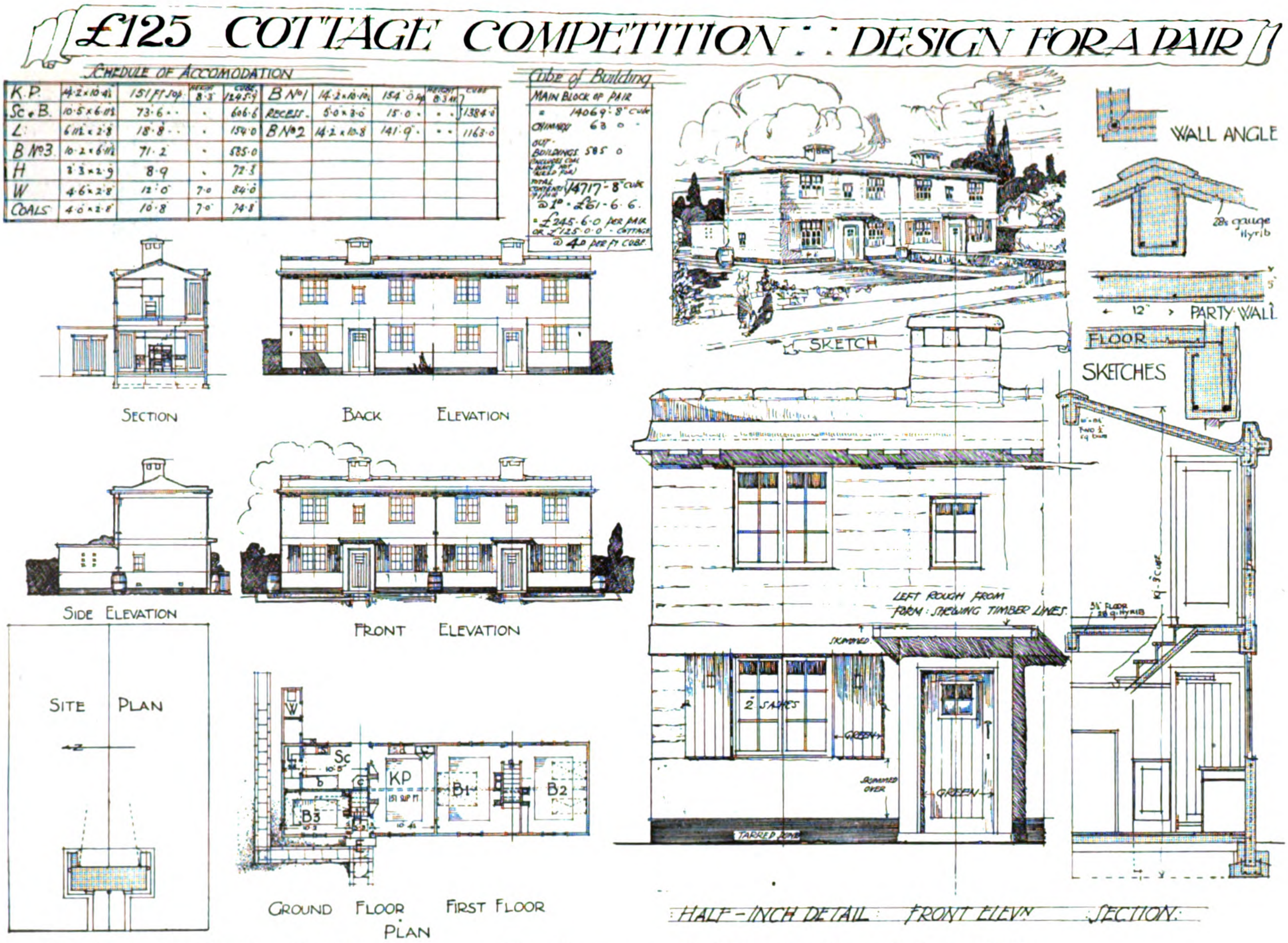
SECOND PRIZE.

NO. 75 DESIGN BY CHAS. BULMAN PEARSON, LICENTIATE R.I.B.A.



SCHEDULE OF ACCOMODATION

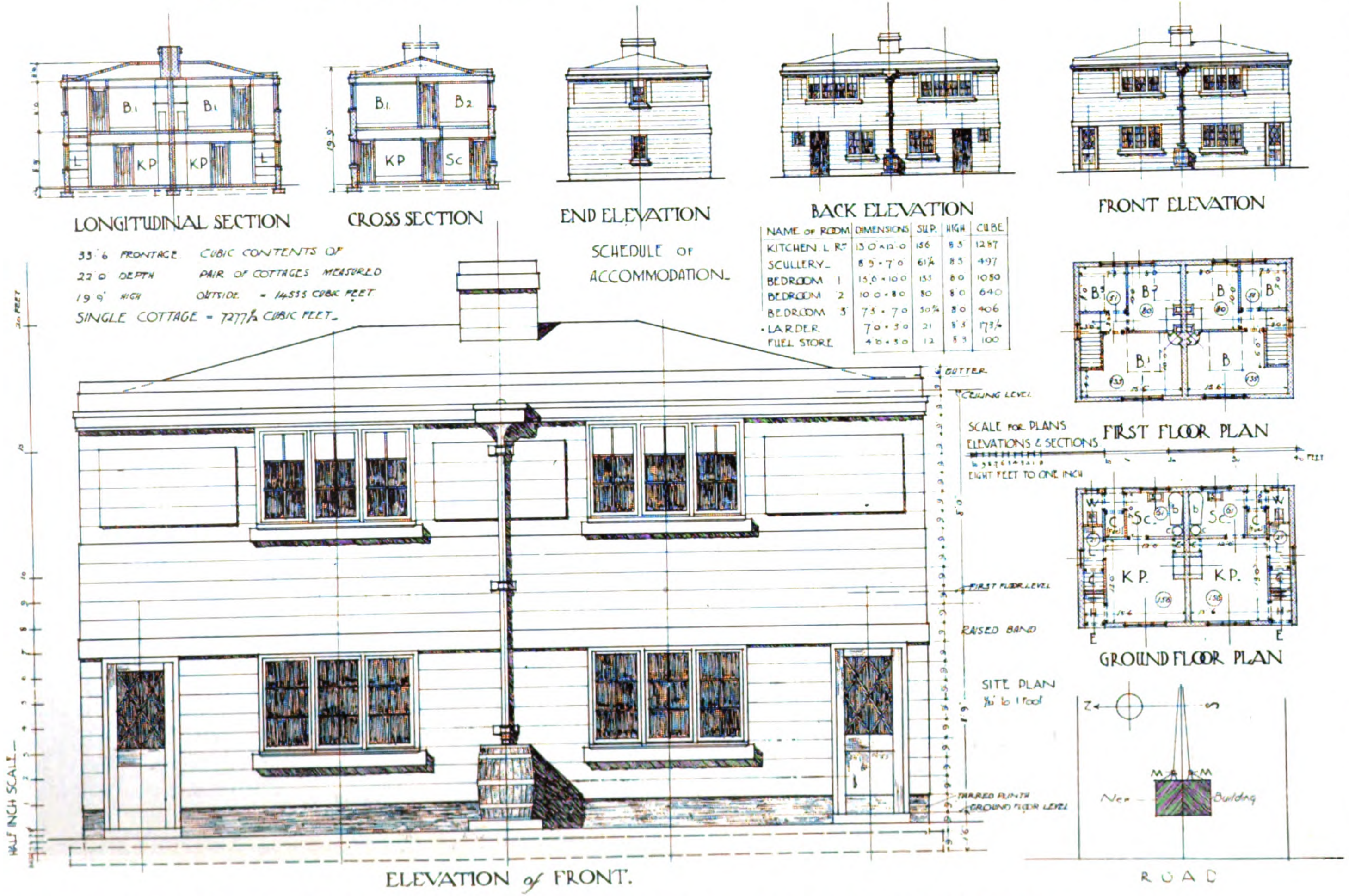
			HEIGHT	CUBE				HEIGHT	CUBE
K.P.	14·2×10·4½	151 ft sup.	8·3	1245·9	B No 1	14·2×10·10½	154·0 ft	8·3 ht	1384·0
Sc & B.	10·5×6·11½	73·6 " "	"	606·6	RECESS.	5·0×3·0	15·0 "	" "	
L	6·11½×2·8	18·8 " "	"	154·0	B No 2	14·2×10·8	141·9 "	" "	1163·0
B No 3	10·2×6·11½	71·2	"	585·0					
H	3·3×2·9	8·9	"	72·3					
W	4·6×2·8	12·0	7·0	84·0					
COALS	4·0×2·8	10·8	7·0	74·8					

Cube of Building

MAIN BLOCK OF PAIR
= 14069'·8" cube
CHIMNEY 63 0 "
OUT-BUILDINGS 585 0
(INCLUDES COAL & W.C. NOT REQD FOR)
TOTAL CONTENTS OF PAIR 14717'-8" cube
@ 1d = £61-6-6.
= £245·6·0 per pair
or £125·0·0 - cottage
@ 4d per ft cube.

Copyright of Concrete Publications, Limited.] THIRD PRIZE .. No. 193 DESIGN BY HAROLD G. HOLT, A.R.I.B.A.

CONCRETE COTTAGE COMPETITION



33' 6 FRONTAGE. CUBIC CONTENTS OF
22' 0 DEPTH PAIR OF COTTAGES MEASURED
19' 9" HIGH OUTSIDE = 14555 CUBIC FEET.
SINGLE COTTAGE = 7277½ CUBIC FEET.

SCHEDULE OF ACCOMMODATION.

NAME OF ROOM	DIMENSIONS	SUP.	HIGH	CUBE
KITCHEN L. Rm	13 0 × 12 0	156	8 3	1287
SCULLERY	8 9 × 7 0	61¼	8 3	497
BEDROOM 1	15 6 × 10 0	155	8 0	1050
BEDROOM 2	10 0 × 8 0	80	8 0	640
BEDROOM 3	7 3 × 7 0	50¾	8 0	406
LARDER	7 0 × 3 0	21	8 3	173¼
FUEL STORE	4 0 × 3 0	12	8 3	100

FOURTH PRIZE DESIGN ... No. 205 BY LEONARD G. HANNAFORD.

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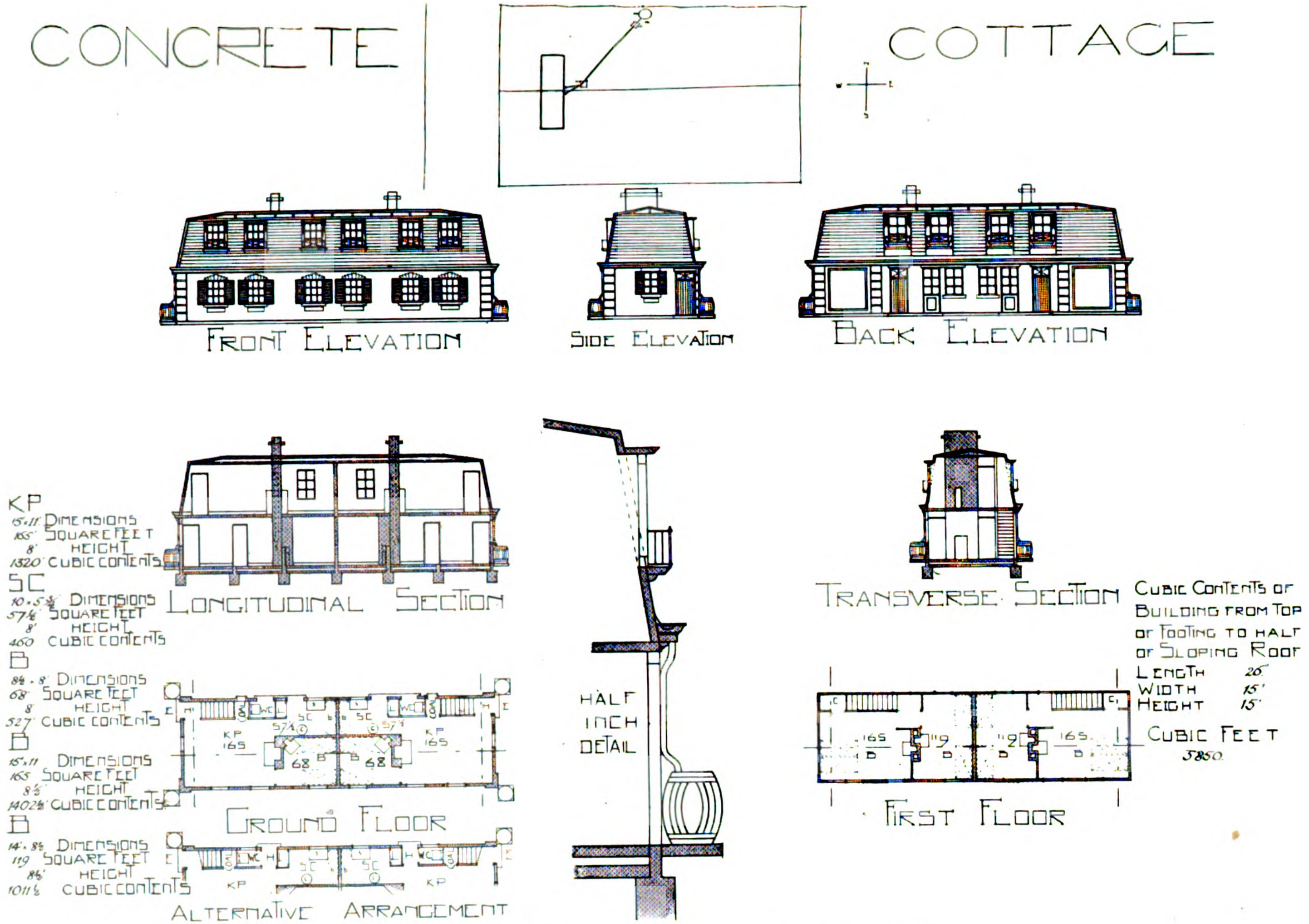

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FIFTH PRIZE DESIGN ... No. 56 BY M. CROSNIER.

SPECIFICATIONS TO COMPETITION DESIGNS.

With Design No. 206 (By Ernest S. Thompson, Architect).

In accordance with the published conditions, I have pleasure in submitting herewith a sheet of drawings illustrating a cottage which provides all the accommodation asked for, is economically planned, sound, cheap and substantial; is one storey high, with a minimum use of timber, has good square rooms, and no dark corners. Each cottage is detached, and is placed on the site so that every living room gets the full benefit of a southerly aspect. The bedrooms also are lighted with due consideration.

The external walls are of 4½ in. solid concrete blocks and breeze concrete partition slabs 2½ in. thick, with a 2-in. cavity in between, well tied together. These slabs would also be used for the partition walls.

The external treatment is extremely simple, depending more for effect upon proportion and shadow, than the use of architectural adornment.

The floors of bedrooms are covered with 1-in. grooved and tongued boarding, nailed direct to the breeze concrete.

The other floors would be finished in granolithic, or concrete tiles.

All internal surfaces of walls would be skimmed one coat, the boarded ceiling stained and varnished.

The drawings will be found quite explanatory of all other necessary points.

Specification.

Excavator.—Excavate site to a depth of 12 in.

Excavate for drains.

Provide and lay concrete beds under footings of external walls 2 ft. by 6 in. thick, composed of 1 part Portland cement to 6 parts of approved pit gravel, not exceeding 1½ in. gauge, with sufficient sand to fill the interstices.

Concretor.—Provide and lay concrete bed 4 in. thick, composed as before, under the surface of all floors.

The floors to the three bedrooms to be finished with 2 in. of fine coke breeze cement; the remaining floors with floated granolithic surfaces. All steps to be in concrete; ditto hearths.

Lintels to windows and doors to be in concrete, reinforced with steel joists, or bars, as may be deemed necessary.

The quoins to all external angles of walls to have rock-faced surfaces, the remaining blocks of walling to be plain-faced.

The plinth to be finished with chamfered course, as shown on detail.

The remaining walls internally, such as fireplace openings, etc., to be formed with concrete bricks; the fireplaces to have fireclay brick linings.

Chimney cap to be plain, splayed and throated, and the crow-steps to chimney on west elevation to be plain 3-in. slabs, weathered and throated.

The concrete flat to roof to be formed of an average thickness of 3½ in., with a surrounding kerb and one outlet to rain-water pipe.

"Self-centering" has been adopted, with a view to economy and efficiency, and to obviate the use of temporary wooden shuttering.

Provide and coat the external surface flat roof with three coats of Ironite waterproofing compound.

Carpenter and Joiner.—The timber for all joiner's work to be best quality yellow deal, with the exception of the ceiling boarding, which will be grooved, tongued and beaded match-boarding, in narrow widths.

Door and window furniture to be of a substantial character.

Plasterer.—The whole of the internal surfaces of the walls to have one coat of skimming, with the exception of the fuel store and w.c., which would be lime-washed.

Plumber, Painter and Glazier.—Plumbing work to be of the best character. All glass to windows 21-oz. sheet.

All external and internal woodwork and ironwork to be painted three coats best oil paint, in addition to stopping and priming.

List of Fittings, etc.

		£	s.	d.
Kitchen Range	p. c.	4	10	0
Fireplaces and Mantels	,, ,,	3	0	0
Sink	,, ,,	1	0	0
Shelving...	,, ,,	2	10	0
Door Furniture	,, ,,	2	10	0
Windows, do.	,, ,,	2	0	0

Statement of Cost.

To arrive at a fairly approximate estimate of the cost, I have taken out a bill of quantities, which I have priced upon established figures, with a due regard to the conditions stated, viz., the buildings are to be erected by the employer's own labour, without the introduction of a third party, and that no main drainage, or gas or water supply, or any plumbing or sanitary work, or equipment other than a length of 40 ft. of 4-in. drain is required, and I beg to append a summary thus obtained of the cost of each trade, inclusive of all fittings :—

	£	s.	d.	£	s.	d.
Excavator and Drainer				4	0	0
Concretor:						
Walling	35	0	0			
Foundations	15	0	0			
Roof	25	0	0			
Floors	5	0	0			
				80	0	0
Joiner:						
Windows	10	0	0			
Doors	10	0	0			
Ceiling	10	0	0			
Floors	3	10	0			
				33	10	0
Plumber, Painter and Glazier				8	0	0
				£125	10	0

With Design No. 75 (By Chas. Bulman Pearson, Licentiate R.I.B.A.).

Description and Remarks.—The author has endeavoured to carry out the conditions of the Competition. The areas of the rooms have been closely adhered to and the accommodation provided is, in his opinion, consistent with cost.

Concrete to be used wherever possible and the amount of woodwork reduced to a minimum. This being necessary in the case of doors, cupboards, etc.

It is proposed that the floors and roof be of concrete, the floor surfaces to be finished with a patent composition such as "Doloment" or other approved method.

The roofs to be covered with approved concrete tiles. If not contrary to the spirit of the Competition, it is suggested that a good coloured red tile would form a very fine contrast to the other portions of the buildings.

The walls and chimney stacks to be in concrete built *in situ*, the interior partitions to be in slab concrete. The external faces of the walls, where shown on drawings, to be finished in plaster or rough-cast trowelled smooth.

All woodwork has been eliminated from windows, the method proposed being shown on the details.

Specification.

Materials.—The cement to be best Portland complying with the requirements of the specification adopted by the British Engineering Standard Committee.

The sand to be from a well-known local pit; it should be clean and free from organic or earthy matter and washed if required. The aggregate to consist of a good local material consisting of gravel, hard stone, or other suitable material; this should be clean and regular, varying in size, all to pass through a ¾-in. mesh.

The proportions of concrete should consist of 1 part cement, 1½ of sand, to 2½ parts aggregate.

The concrete should be mixed in small batches and in accurate proportions, and should be laid as rapidly as possible.

The amount of water to be added depends on the temperature at the time of mixing. Clean fresh water only to be used.

The centering or casing to be so constructed as to remain rigid and unyielding during the laying and punning of the concrete, and should be arranged to permit of casing and removal without jarring of concrete.

All other materials to be the best of their respective kinds, free from all defects.

List of Fittings, etc.

	£	s.	d.
Kitchen Range	3	0	0
Washing Copper	1	10	0
Bedroom Fireplaces (3)	4	0	0
Dresser	2	0	0

Statement of Cost.

The cubical contents are 14,194 cu. ft. the pair.

This is arrived at as follows :—

		Ft.
Main Block	73 ft. 3 in. x 15 ft. 6 in. x 11 ft. 6 in. =	13,057
Entrances (2)	5 ft. 0 in. x 3 ft. 6 in. x 11 ft. 0 in. =	385
W.C.	7 ft. 6 in. x 11 ft. 0 in. x 9 ft. 0 in. =	776
Chimney Stacks	3 ft. 6 in. x 2 ft. 6 in. x 5 ft. 6 in. =	144
		14,362 per pair

Estimated cost per pair—

= 14,362 cu. ft. at 4 1-6d. = £249 6s. 10d.
= £124 13s. 5d. per cottage.

It is considered that the price per cu. ft., 4 1-6d., is sufficient, seeing that there is no fencing, paths, water supply, plumbing, or land drainage to be included, and that the cottages are to be put up in a series of six.

With Design No. 193 (By Harold G. Holt, A.R.I.B.A.).

The cottages shown on the accompanying drawing have been designed in accordance with the conditions, and with a view to strict economy, combined, so far as possible, with a reasonably pleasing appearance, suitable for rural districts. The author has made an effort to get away from the somewhat box-like appearance which follows a flat roof treatment in a small building.

Standardisation.—In planning the cottage the view was to repeat the parts as much as possible. On consideration the author decided that to merely design a cottage suitable for brickwork, timber and slated roof, and label it "concrete block cottage," though allowable under the conditions, was not advancing the purpose of the Competition very far, and made an effort to design a cottage where repetition of parts would enable it to be economically built, with outside walls, etc., of concrete moulded horizontally (see specification).

The accommodation shown complies with the conditions, and is substantially that reported as desirable by the Departmental Committee which investigated the Small Holders' housing question.

Through ventilation is obtained in the best rooms and staircase. Owing to the low thermal conductivity of concrete, the cottage would be cool in summer and warm in winter. Water-tightness obtained by careful grading, etc., and oil-mixed finish suggested if in wet locality.

Specification.

Concrete.—Cement for concrete to be Portland, to British Standard Specification, medium setting.

Aggregate (according to locality) to be clean, hard, broken ballast or gravel and sand, free from loam, etc., carefully graded by experiment, and all to pass ½-in. screen. Mixing to be in proportion of 4 to 1 by measure, mixed on clean wood bankers (or in hand-power mixer if available) while dry until thoroughly incorporated, water to be then added by spray, and mixing continued until the concrete is even in consistency and in a semi-fluid state.

Reinforcement.—In outside walls and beams ½-in. rods and steel wires 12 S.W.G. In floor and roof Hyrib lathing, 28 S.W.G.

Method of Construction and Waterproofing.—Foundation of 6 to 1 concrete to be laid in trench with rebate 7 in. wide and 3 in. deep. Horizontal close-boarded wrought sheeting as form to be laid with base line near trench on strong planks (sheeting of 6-in. by ⅞-in. boards, to be used for flooring at completion) soft-soaped for concreting.

Concrete carefully tamped in 2½-in. layer; reinforcement laid on 2½-in. layer again. If in a wet locality it is suggested the finishing ½ in. should be oil-mixed concrete (heavy petroleum residuum). The window sashes and door frames to be bedded in moulds and concreted up to. Surface screeded off. Concrete allowed to set for at least four days, then sheeting drawn away. Allow to season and raise in position with block, legs and tackle by ropes tied to planks (which protect the surface and distribute the weights), and slipped into rebate in footings. Strutted up and grouted in. Three types of forms, as sketch. Joint made by rod grouted round at junction of each moulded piece.

First floor and roof 3½-in. Hyrib 28 gauge lathing concreted in.

Partition between scullery and bedroom No. 3, Hyrib plaster skimmed both sides, finishing 2 in.

Roof finished with ¾-in. oil-mixed concrete.

Flues and walls next stair of brickwork.

Floors.—Kitchen and bedrooms to have centre boarded square, of 6-in. by ⅞-in. imported Baltic white, square jointed and laid in tar as blocks; ⅞-in. cement finish round, and to all other rooms.

Windows.—2-in. red deal standing sashes (or fast sheets), no frames. All out of 4-in. by 2-in. casements cut out. Mill made. Glazing, 21-oz. sheet.

Doors.—⅞-in. T and G boards on 1½-in. battens. Mill made.

Stairs.—1-in. tread, ⅞-in. risers on 3-in. concrete carriage, for fire protection.

Walls lime-whited outside, plaster skimmed one coat inside.

External wood, prime and paint three coats oils; internal, prime and paint two coats.

List of Fittings, etc.

The following net p.c. sums are included in estimate :—

	£	s.	d.
No. 2 Kitchen Ranges, @ £2 10s.	5	0	0
No. 4 C. I. Mantel Registers to Bedrooms 1 and 2, @ 16s.	3	4	0
Ironmongery for each Cottage, @ £2 10s.	5	0	0
No. 3 R. W. Butts, @ 15s.	2	5	0
No. 2 Kitchen Dressers, 4 ft. 3 in. x 2 ft. 9 in. x 1 ft. 4 in., @ £2	4	0	0
No. 2 Kitchen Cupboards, @ £1	2	0	0
No. 4 Small Cupboards, @ 7s. 6d.	1	10	0
	£22	19	0

Estimate of Cost.

£250 the pair—arrived at as follows :—

A. Building cubed outside measure and 19 ft. 3 in. high from bottom of footings.

14,717 cu. ft.	£	s.	d.
At 4d. per ft. cube	245	6	0
Contingencies, say	4	14	0
	£250	0	0

B. Rough quantities taken and priced out by author from reliable information. Following are the items condensed. Prices for concrete for walls, etc., including sheeting and reinforcement, given by a reliable builder at 43s. per cu. yd., checked by price obtained from a person who has actually carried out this type of construction three years ago with walls 6 in. thick at 5s. per yd. super. Allowing 20 per cent. advance in prices, the author considers it on right side (the building owner being the direct employer and the economy in sheeting) in putting this concrete at £2 2s. per cu. yd.

Schedule.

	£	s.	d.
Excavating and Drains	3	10	0
Wall, Floor and Roof Concrete, @ £2 2s. per yd. cube	127	13	0
Foundation and Ground Floor	13	1	6
Brickwork	10	10	0
Cement Floating, etc.	5	0	0
Wood Floors	5	13	0
Windows and Glazing	15	6	8
Door Frames, internal joinery	21	2	6
Hyrib, Plastering and Painting	20	18	6
P.C. sums as per list	22	19	6
	£245	14	8

This allows of a sum of £4 5s. 4d. being placed for contingencies if required, or towards plumbing and fencing.

With Design No. 205 (By Leonard G. Hannaford).

The author has designed the cottages with a view to absolute economy in administration, as well as of construction and upkeep, the accommodation being within a rectangle without any outbuildings. The fireplaces are grouped together so as to form one central stack serving the pair of cottages.

As well as a large kitchen-living room there is a scullery fitted with copper, bath and sink, a fuel store well placed, and large larder, and cupboard for food.

The staircase is convenient and easy; the upstairs landing is reduced to a minimum, which gives all available space to the bedrooms.

The position of the w.c. is at the rear of the cottage, and entered from the back porch, and the whole of the plumbing and drainage work is compact and therefore inexpensive.

The general treatment is of a symmetrical and simple character, and an endeavour has been made to make the elevations quiet and pleasing in effect.

Specification.

The foundations shall be of concrete, proportioned 1 : 2½ : 5 and filled into trenches 18 in. wide, dug for the purpose. The walls generally are to be formed of hollow concrete blocks 9 in. deep and 10 in. thick, set in cement. The mixing is to take place upon a raised wooden platform, the ingredients turned over twice dry and once after wetting, and to be filled into the moulds within twenty minutes from time of mixing. The cement used must be Portland, and of approved brand and manufacture, and to comply with the " British Standard Specification ". aggregate to be the best obtainable locally, and to be carefully graded. All sand to be clean, sharp, pit sand, free from loam.

The moulded band at the roof level to be run with Portland cement and sand, 1 to 2 on rough concrete blocks; the blocks forming the plinth are to be set back slightly and tarred, and the projecting band at the first floor level to be left projecting, as shown on drawings.

Blocks forming the lintels of openings to be reinforced with ½-in. bars set 1½ in. from the soffite.

The ground floors to be of Portland cement concrete laid over site to a depth of 4 in., proportioned 1 : 2½ : 5, and finished with a layer of Portland cement and fine sharp aggregate, 1 to 2. The stairs are to be of concrete, cast *in-situ,* and reinforced across with ⅜-in. bars.

The first floor to be of 5-in. Portland cement concrete reinforced with expanded metal. The partitions are all to be formed with patent concrete slabs 3 in. thick.

The roof to be of concrete, 1 : 3 : 5, reinforced with expanded metal and at intervals with ½-in. bars; the concrete used in this to be treated with " Ceresit " or other patent waterproofing material. The ceilings over first floor to be formed of 2-in. concrete on expanded metal,

All internal walls and ceilings to receive a skimming coat of plaster, except those of scullery, fuel store, and w.c., which are to be whitewashed.

The whole of the internal joinery to be stained to the colour of dark oak. The external woodwork to be painted.

The floors of the bedrooms to be floated ½ in. of cement to receive linoleum.

Exterior walls to be whitewashed.

	£	*s.*	*d.*
3 ft. Kitchen Range	2	10	0
2 Water Butts	1	10	0
Bedroom No. 1, Grate and Mantel	2	0	0
Bedroom Grate and Mantel	1	15	0
Ironmongery	2	5	0
	£10	0	0

Particulars of Cubing, etc.

Length of pairs on Frontage ... ... 33 ft. 6 in.
Depth of Cottage ... ... 22 ft. 0 in.
Height :—
Bottom of footings to Ground Floor level ... 1 ft. 6 in.
Ground Floor to First Floor ... ... 8 ft. 9 in.
First Floor to ceiling ... ... 8 ft. 0 in.
Ceiling to half up roof ... ... 1 ft. 6 in.
19 ft. 9 in.

33 ft. 6 in.
22 ft. 0 in.

737 ft. 0 in. sup.
19 ft. 9 in.

14,555 ft. 9 in. cube in pair of Cottages.

14,555¾ cube ft. at 1d. = £60 13 0 per pair.
14,555¾ cube ft. at 4d. = £242 12 0 ,, ,,

Cost of one Cottage ... £121 6 0

With Design No. 56 (By M. Crosnier).

Description of the Building.—In the accompanying design the cottages are arranged in semi-detached blocks. The entrance doorway, placed in a lobby formed in the side elevation, gives immediate access to the staircase leading to the rooms on the upper floor and indirect access to the well lighted combined living room and kitchen (15 ft. by 11 ft.), containing a floor area of 165 ft. This room forms the approach to bedroom (8 ft. 6 in. by 8 ft.), containing a floor area of 68 ft. and suitably arranged for two beds, and to the scullery (10 ft. by 5 ft. 9 in.), which has a floor area of over 57 ft., and is fitted with a copper, sink, and bath, the latter being sunk below the level of the floor and covered with a hinged top to close flush with the floor when the bath is not in use

The coal store, accessible both externally and internally, is placed under the stairs, and the larder is entered from the scullery; but, for sanitary reasons, the w.c. entrance is external (see description of the alternative arrangement).

There are two spacious bedrooms upon the first floor, the larger of which (15 ft. by 11 ft.) has a floor area of 165 ft., and the smaller (14 ft. by 8 ft. 6 in.) one of 119 ft. Each bedroom is planned for two beds, the larger room is fitted with a spacious cupboard, and all three bedrooms have fireplaces.

A simple architectural treatment, consistent with the limitations of the cost of the proposed building, has been adopted, and it is hoped that the quoined concrete walls and boldly moulded cornice, in combination with the red concrete tiles of the mansard roof with its balconettes for flowers, and the green shuttered lower windows, will tend to produce a simple and homelike effect.

Alternative Arrangements.—An alternative arrangement is shown upon the drawing under which there is no direct external entrance to the scullery, and the w.c. is entered under cover from the adjoining lobby. This arrangement makes the scullery less cramped for working purposes.

Outline Specification.

Foundations and Walls.—Construct the walls in the manner shown upon the drawings, the concrete walls above the foundations being cast vertically *in-situ* between temporary boarding 2 in. in thickness, stayed by 4-in. by 2-in. vertical supports and 4-in. by 3-in. struts resting on cleated sole plates. Care must be taken not to strike the timber shuttering for any section of the walling before the concrete has become thoroughly set. All door and window frames must be carefully placed in position and the concrete walls formed round them.

The concrete used for the walls and foundations is to be mixed in the following proportions, viz. :—

One part of Portland.
Three parts of approved sand.
Six parts of approved clean broken bricks or ballast gauged to pass through a 2-in. ring.

The above materials are to be carefully selected, and the Portland cement is to be of approved manufacture and strength.

The cement and sand are to be first well mixed together, then the aggregate is to be added and thoroughly incorporated, water being then played on from a nozzle and the mixture turned over until it becomes a plastic mass.

Reinforced Floor and Roof.—The floor and roof are to be constructed of concrete, as before, with the addition of sufficient steel work to resist the tensile stresses induced.

Ground Floor Paving, etc.—Form a bed of concrete, as before described, and 6 in. in thickness, to receive the ground floor paving, which is to be of Portland cement and sand trowelled smooth. Paving of this description will be used in the scullery, w.c., coals, and lobby.

Concrete Roofing Tiles.—Cover the mansard roof with patent red concrete grooved interlocking tiles.

Moulded Cornice, etc.—Carefully run the main cornice and other mouldings in accordance with a template prepared from a full size drawing with a mixture of Portland cement and sand on a proper core of concrete.

Staircase.—The staircase is to be formed of solid concrete steps, cast *in-situ* and finished with a finely trowelled surface.

List of Fittings and their Prime Cost.

	£	s.	d.
1 Cottage Range and Mantel	2	10	0
3 Register Grates and Mantels	2	5	0
5 Small iron Balconnettes	2	10	0
2 Water Butts	1	0	0
	£8	5	0

Statement of Cost.

The cubic contents, measured as directed from the top of the foundations to half-way up the attic roof, amount to 5,850 ft., which, at 6d. per foot, equals £123. The author is convinced that one of the cottages can be erected in accordance with the accompanying design and under the given conditions for the amount named, viz., £125.

REFERENCES ON DRAWINGS.

B	Bedroom.	m	Manhole.
Bt	Bathroom (if any).	E	Main entrance.
L	Larder or food-store (if any).	H	Hall, lobby, or anteroom (if any).
C	Cupboard or closet (if any).	K	Kitchen.
W	W.C.	P	Living-room or parlour (if any).
d	Dresser (if any).	KP	Combined living-room and kitchen (if any).
c	Copper (if any).	Sc	Scullery or wash-house (if any).
s	Sink.		
b	Bath (if any).		

THE TESTING OF REINFORCED CONCRETE BEAMS.

By JOHN A. DAVENPORT,
M.Sc., A.M.Inst.C.E., etc.

In this article the author desires to show how necessary it is, in the interests of reinforced concrete, that research work should be conducted on some uniform lines and that all tests should be systematised.—ED.

Introduction.—Engineers, architects, and others interested in the development of reinforced concrete as a structural material often differ in opinion upon various points regarding strengths, methods of reinforcing, and similar things; but upon one point opinions coincide, and that is the necessity for systematic and extensive experiments on reinforced concrete structural members of all kinds. A large amount of work has already been done by experimenters in different parts of the world, but owing to the greatly diverse conditions, chiefly differences in the qualities of the concrete tested, they cannot be regarded as supplementary in any way. It is chiefly on this account that opinions differ, to such a great extent, upon many important points upon which there should be complete accordance. If all the experiments on beams, columns, and similar structural members built of reinforced concrete had been made on the same quality concrete, say, 1 : 2 : 4, made with the same kind of aggregate and Portland cement, our knowledge of the subject would have been much more valuable, from a practical point of view, than it is at present. It would clearly be impossible for experimenters in all parts of the world to use the same aggregate and Portland cement; but it would have been possible to have had these materials so much alike in properties, sizes, etc., that the results would all have been supplementary.

Had all the published experiments on reinforced concrete been systematised in this way, it is probable we would now know as much about that particular quality of concrete when reinforced as we know about steel; and then the extension of the work to other concretes would have been comparatively easy, because the completed series of experiments would indicate the best lines to follow.

Of course much valuable work has been done by experimenters on different aggregates, cements, and so on, but these refer to concrete and not to the composite structural material now known as reinforced concrete.

Necessity of Systematising.—It is therefore suggested that it is not too late to systematise all experiments, and that for some time to come all experiments on reinforced concrete (this suggestion excludes plain concrete), should be made on a standard steel and a standard concrete. By standard steel is meant one having particular ultimate strength, yield point, elongation, and contraction. These could vary between limits, but the variation should be kept small. By standard concrete is meant one made of one particular coarse material, one particular sand, and one particular cement, always mixed in the same proportions with the same amount of water. The coarse material should always have the same sizes and grading, and the sand should likewise have definite sizes and grading which must always be the same

Fixing of Standards.—The fixing of the standards should be the work of the Institution of Civil Engineers, the Concrete Institute, or some similar engineering body which is interested in the material in an engineering sense.

Steel.—Probably mild steel would be best as the standard steel, and it would have to be specified as regards ultimate strength, yield point, elongation, and contraction. The effect of welding, splicing, variation of size, different sections, anchorage of ends, corrugations or projections, disposition of shear reinforcement, and general method of arranging the bars would be matter for experiment.

Concrete.—For the concrete, the coarse material would have to be specified as regards material, sizes, and grading; the sand as regards material, sizes and grading; the cement as regards fineness, setting time, strength, and soundness. The percentage water and proportions of the solid material would also require specifying. If graded materials were used, and this is preferable, probably a leaner mixture than 1 : 2 : 4 would be better for the standard concrete. The mixing, casting, and treatment of the concrete subsequent to casting are important, and should also be specified. Finally the age at which testing takes place should be specified, recommendations regarding the methods of testing might be given, and forms of log sheet for recording the results of experiments, in order that such results may be supplementary to the work of other experimenters, and therefore of the greatest possible value.

Manner of Making Experiments.—The manner in which experiments are made is a question which requires more attention than it has apparently received in the past. Experiments may be made in two ways—viz., scientific and practical—and the results may or may not coincide. If they be made in the laboratory upon single units, and with all the refinements of load application made possible by the scientific apparatus now available, the results will be laboratory results. But if, on the other hand, they be made, either in the laboratory or elsewhere, upon a combination of units, such as used in practice, either full size or to small scale, and the loads are applied in a practical instead of a laboratory manner, the results will be practical. In the case of many structural materials these two sets of results will coincide, more or less; but with reinforced concrete they will be widely different in the majority of cases.

Reinforced Concrete.—Reinforced concrete stands alone as a structural material by virtue of its monolithicity, and it is seldom that this property is absent from any practical application of the material. Champions of reinforced concrete are ever ready to speak of this monolithic character of the material, and the advantages derived therefrom; but they apparently forget that the rules upon which designs are based were derived from experiments upon units which, almost without exception, did not possess this property. The result is that structures designed in accordance with such rules have nominal factors of safety which are different, in many cases much different, from the actual factors. This as a rule means erring on the right side, so far as strength is concerned; but it suggests that the nominal factor should be given one of its old names—viz., " The factor of our ignorance."

It is an undoubted fact that reinforced concrete, as applied in structures to-day, owes much of its strength to its monolithic nature, which should be regarded as of only slightly less importance than its compressive strength. It is therefore urged that in all experiments on the material this property should be taken into account in the only possible manner—that is, by testing only monolithic collections of units, either full size or to small scale. The testing of reinforced concrete structural members subjected to bending, which may all be classed as beams for brevity, is probably of greatest importance, inasmuch as they form the larger part of structures generally, and may be subject to such varieties of treatment.

Reinforced Concrete Beams.—Beams may be divided into several classes based upon different features, and it is not at all clear from existing experiments which should be regarded of primary importance. For example, they may be divided into continuous and non-continuous beams, and then sub-divided firstly into plain and T-beams, and secondly into singly reinforced and doubly reinforced beams. Or either of the latter sub-division classes may be taken as the chief division and the two remaining classes as sub-divisions. Then there may be further sub-divisions based upon the qualities of the concrete and steel, the method of loading (either concentrated or distributed), and so on. The necessity for considering all these sub-divisions of the subject may seem an extraordinary state of affairs, but then it must be remembered that we are dealing with an extraordinary structural material, and one which, on account of its monolithicity, does not resemble other materials in its properties.

It is probable that the chief division will be into continuous and non-continuous beams, owing to the great effect of variation of moment of inertia, change of section, and monolithicity. Existing experiments are not sufficient as regards number and corroboration to enable us to state anything definite about the sub-divisions, but they indicate that plain beams act very much like T-beams, that singly and doubly reinforced beams act in very much the same way, and that different concretes and steels do not affect the action of reinforced concrete beams to any great extent.

The following division of the subject is suggested as probably the best method of classification. It will be noted that standard concrete and steel are used, so that sub-divisions relating to their effects are eliminated.

Classification. — Classification of reinforced concrete beams, built of standard concrete and standard steel, designed for systematic experimental research :—

Class 1.—Continuous Beams. *Class 2.*—Non-continuous Beams.

Sub-division (a) (a_1) Plain Beams.
(a_2) T-Beams.
Sub-division (b) (b_1) Single Reinforcement.
(b_2) Double Reinforcement.
Sub-division (c) (c_1) Distributed Load.
(c_2) Concentrated Load.
Sub-division (d) (d_1) Vertical Stirrups.
(d_2) Inclined Stirrups.
Sub-division (e) (e_1) Plain Bars.
(e_2) Deformed Bars.
Sub-division (f) (f_1) Plain Bar ends.
(f_2) Hooked or Bent Bar ends.
Sub-division (g) (g_1) Large number of Small Bars.
(g_2) Small number of Large Bars.
Sub-division (h) (h_1) Rectangular Sections (Bars).
(h_2) Circular Sections (Bars).

Thus an experimental beam $2\ a_2\ b_1\ c_2\ d_2\ e_1\ f_2\ g_1\ h_2$ would be a non-continuous T-beam, carrying concentrated loads, and singly reinforced with a large number of small round bars with hooked ends, and inclined stirrups.

Tests Required.—The foregoing classification comprises 512 different types of beam, and taking two of each, this would involve 1,024 tests, which is undoubtedly a gigantic work, but by judicious elimination it can be much shortened. So far as our present knowledge goes we could probably regard sub-divisions e, f, g and h as being relatively unimportant at first, and lump them all together in the following order : e_1, f_2, g_2, h_2, and this would then leave 32 different types of beams. Taking two experiments for each type would involve 64 tests, a work which could be fairly easily handled by four or more experimenters. These tests would be in the nature of preliminary work, conducted with a view to showing in which directions the research should be concentrated and in which they should be relaxed, so that the fullest and most reliable information could be obtained with the least expenditure of time and money.

The results to be aimed at.—The object of all engineering research is, or should be, to gather information which will enable engineers to benefit the community to the greatest extent with the materials they have at their disposal. Thus the claims of the community are paramount, and if engineering research generally be measured by this standard it will be found that it satisfies it, sometimes directly and at others indirectly. Experimenters often have a knack, happily or unhappily depending upon the point of view of the person considering the matter, of branching off into side tracks which are of more scientific interest than the utilitarian main path, and the greater benefit which might accrue from their work is delayed. But the mere fact that they acquire knowledge of the workings of nature must be for the general good although it may not be apparent at the time. There are cases, however, in which this digression is undesirable, and perhaps the most urgent case is that of research in reinforced concrete. Thus it is urged that the following five quantities should be continually kept in sight as the goal to be striven for :—

(1) The moment of resistance of the section.
(2) The bending moment at any section.
(3) The deflection at any point.
(4) The shear resistance at any section.
(5) The shear force at any section.

If, at the same time, observations can be taken which will lead to results of more scientific interest, they may be; but they should be regarded as of secondary importance.

The Moment of Resistance.—The moment of resistance is often expressed in the form—

$$R = \mu bd^2$$

and this seems to be the best possible. Experiments should therefore be directed to show, firstly, that the expression is of that form under all conditions, and then to what extent μ is a function of the variable quantities such as shape of section, strengths of steel and concrete, percentage steel, loading and continuity of beam, size, shape and lengths of bars, and so on.

The Bending Moment at any Section.—According to our present knowledge this is expressed in the form—

$$B = k_1 \ wl.$$

and this simple form should be retained if possible. Experiments should therefore be directed to show that the form is, or is not, the same under all conditions, and to what extent k_1 is affected by the variable quantities.

The Deflection at any Point.—In the case of homogeneous materials this is given by the expression—

$$\delta = k_2 \ wl^3,$$

k_2 being a function of the moment of inertia and Young's modulus. In the case of reinforced concrete the moment of inertia changes, very often to a great extent, from one end of the span to the other, and experiments should be directed to getting k_2 as a function of something which is less changeable throughout the span.

The Shear Resistance at any Section.—This is usually taken as being expressed by

$$S_r = k_3 \ bd,$$

in which k_3 is a constant. But it is possible that k_3 will be modified more or less by the monolithicity, and experiments should be directed to determining this and any other possible causes of variation.

The Shear Force at any Section.—This is expressed by—

$$S_f = k_4 \ w_1$$

in which k_4 is a function of the position of the section in the span. This again may vary with the moment of inertia and the monolithicity, and experiments should be directed to settle the point.

Manner of Conducting Tests.—The manner in which the tests are carried out as regards the method of applying the loads requires careful consideration because, so far as the writer is aware, there does not exist, in this country at least, a machine suitable for applying both concentrated and distributed loads on several spans simultaneously. Special provision must therefore be made for :—

(1) Distributed loading over one or more spans.
(2) Concentrated loading over one or more spans.
(3) Special facilities for the observation of deflections, cracks, partial and complete collapse, and so on, with the absence of danger to the observers.
(4) The application of loads as nearly as possible in a practical manner.

Regarding the application of loads, it is a well known fact that concentrated loads are usually transmitted to the supporting beams, in practice, through columns or beams; while in the laboratory loads are usually applied directly to beams without the intervention of those elements which tend to distribute them in some way. This applies to one of the effects of monolithicity which may, or may not, affect the laboratory as compared with the practical results, and which should be taken into account in any rational experimental work on the subject. Further, in the application of distributed loads in practice, a slab usually transmits the load to the beam, and the upper surface of the concrete, when the slab forms part of the compression area of the beam section, will be in tension from the bending of the slab, and in compression from the bending of the beam. It is true that this tension in the concrete is not considered in designing reinforced concrete; but it is a fact, nevertheless, that tension exists in the concrete when loaded, and it is only reasonable to assume that it will affect the strengths in some way. The only way, therefore, to get any knowledge of this effect is to combine slabs with beams in the usual way, and to load the slabs all the way across and not only immediately over the rib of the beam.

In order to facilitate observations and eliminate danger, the testing of beams should take place in such a way that bending occurs in the horizontal plane, instead of the vertical plane as usual. This would differ from general practice in the elimination of the effects of dead weight of the structure; but these could be supplied simply and accurately. Against this minor disadvantage there are the advantages relating to the maximum amount of light on one side of the beam in daylight; greater safety and ease of observation at all states of the test; and facilities for placing apparatus on the side of the beam for measurements. There is the possible disadvantage that apparatus is not made for such tests. But then it is probable that there are no machines designed to test beams over several spans and loaded in any manner; so that a new machine would have to be designed for the work in any case.

The distributed loading would have to be distributed not only along the span, but also across the slab monolithic with the beam; and provision would have to be made for applying any number, spacing, and magnitude of concentrated loads.

Conclusion.—The suggested scheme, as set out above, is systematic, practical, and complete, so far as standard materials and beams are concerned; but it will necessarily involve a large expenditure of time and money. On this account the question that will very naturally be raised is : " Is it worth it? "

A brief consideration of the alternatives will probably show that an affirmative answer is the best from every point of view. If the scheme be followed, it will lead to a knowledge of reinforced concrete beams which is definite, complete, and practical; but it will involve the large expense already noted. The return on the outlay will be the knowledge which gives us the means of designing efficiently and economically, and the agreement of engineers on points upon which there are now differences of opinion. It has already been pointed out that reinforced concrete structures are, as a rule, stronger than we suspect, chiefly owing to our incomplete knowledge, and it is highly probable that the saving brought about by a complete knowledge of the subject will be much greater than the cost of the research upon which it is based. This saving by working truly economically is a most important feature, quite apart from the fact that a structure which is stronger than it need be is not an engineering work in the strict sense, as everything points to a boom in the application of reinforced concrete. A further argument in favour of systematic research is the fact that reinforced concrete, unlike other structural materials at any period of their histories, is widely used, but at the same time is still in its infancy. The present time, therefore, offers an opportunity, never before known in the history of engineering, of dealing with the question of research as a whole Then there is the fact that experiments are continually being made, involving expense, which, if systematised, would tend to reduce the cost of a comprehensive scheme. On the other hand, if research be carried out as at present, differences of opinion on many important points will persist for many years; the attainment of the complete knowledge aimed at by the scheme will be delayed indefinitely, and will cost much more; and the amount of money unnecessarily expended on structures, owing to our incomplete knowledge, is incalculable.

The scheme is particularly recommended for beams, as they form the greater part of reinforced concrete structures; but the whole subject should be treated in the same way. The financial side of the scheme, although great, is not insurmountable, and the writer therefore hopes that the very favourable opportunity which now exists will be dealt with by the engineering profession in the only rational and, what one might say, true engineering manner.

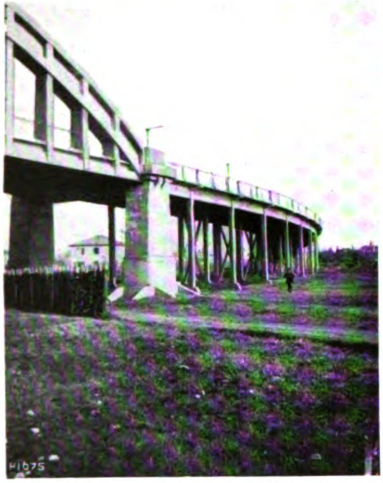


Fig. 1. View of one of the Inclines.

REINFORCED CONCRETE RAILWAY BRIDGE FOR THE MESTRE-MIRANO ROAD OVER THE UPPER VENETIAN RAILWAY, ITALY, and a REINFORCED CONCRETE TRAMWAY BRIDGE, MESTRE, ITALY.

The following description of some reinforced concrete bridge work in Italy may not be without interest. The engineer for these bridges was Mr. G. Pasquali, of Mestre, to whom we are indebted for our particulars and photographs.—ED.

Railway Bridge.—This bridge was erected two years ago and must be regarded as the most ambitious structure of its kind, as it has a total length of 500 metres, with a clear roadway of 8·50 metres, whilst the central span is 41·50 metres between the axes of piers (*Fig.* 5).

The bridge carries a provincial road on the Mestre-Mirano line of tramway over the railway from Mestre to Upper Venice, connecting Italy with Austro-Hungary. The expense of construction has been borne by the province of Venice, the Italian Railways, and the Mestre Tramway Co., the initiative being due to the last-named, as, before the construction of the road bridge had been decreed the Tramway Co. had itself decided to build a tramway bridge.

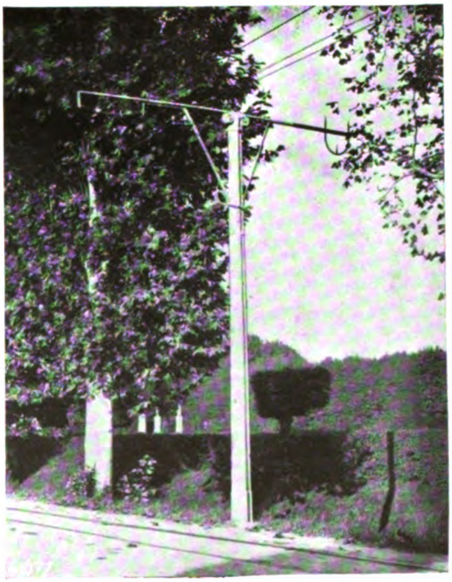


Fig. 2. Reinforced Concrete Tramway Mast.

Reinforced Concrete Railway Bridge, Mestre-Mirano Road, Italy.

The following data were given for the design:—

For computation of the structure the loads prescribed by the Italian Railways, namely:—

1. Weight of a cub. metre of concrete, 2,400 kg.; of macadam, 1,800 kg.; weight of a crowd, 500 kg. per sq. metre.

2. Four-wheeled vehicle with six horses, 8,000 kg. on each axle and 750 kg. for each horse; distance between axles 3 metres; length over all, 16 metres; width, 2·50 metres.

3. Wind: 250 kg. horizontal per sq. metre exposed when unloaded; 150 kg. when loaded.

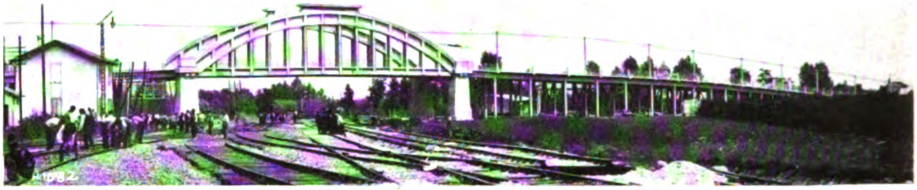


Fig 3. General View of Central Span and one Incline.

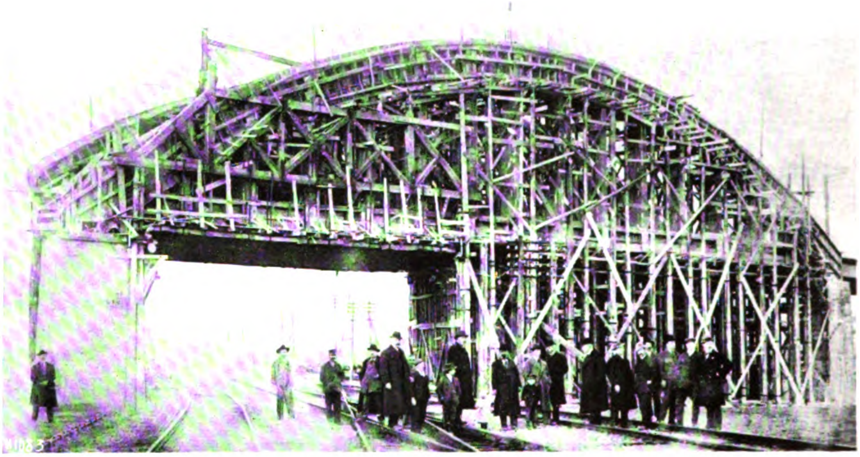


Fig. 4. Centering for Main Span.

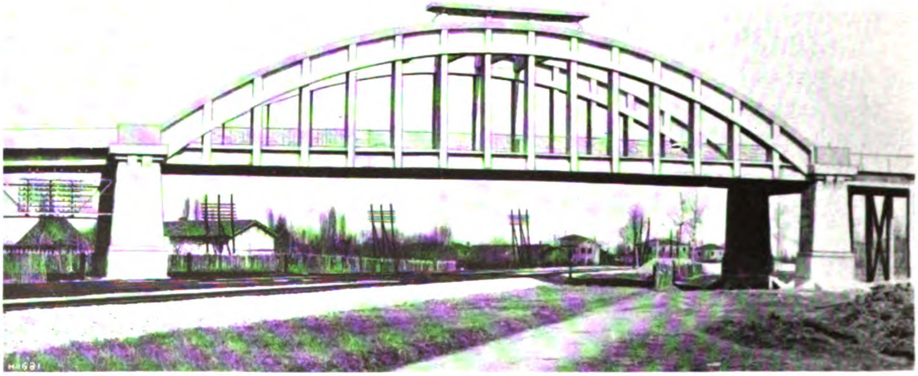


Fig. 5. Central Span.

Reinforced Concrete Railway Bridge, Mestre-Mirano Road, Italy.

4. Tramway: Motor-trams, 8 tons on each axle; trailers, 6 tons; length, 7·50 metres between buffers; distance between axles, 2·50 metres; breadth, 2·50 metres.

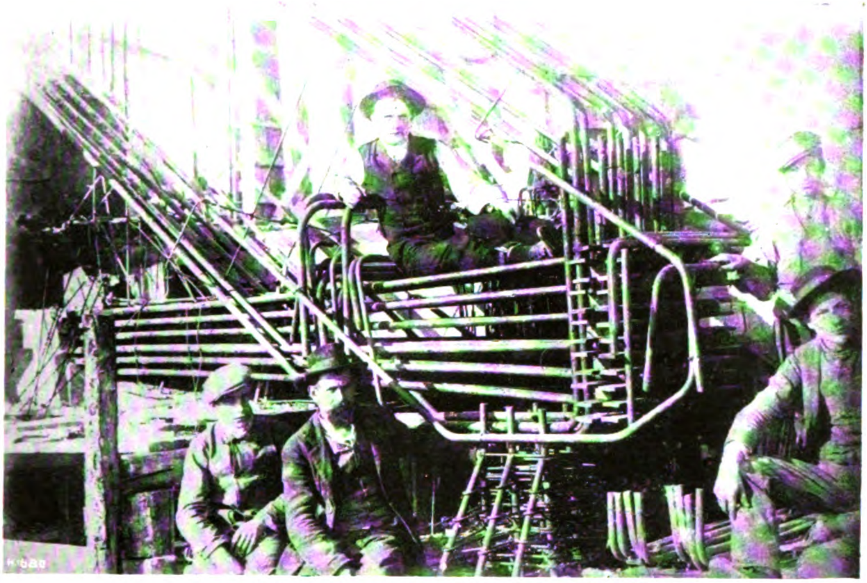


Fig. 6. Reinforcement at Hinged Joint of Bowstring Girder.
REINFORCED CONCRETE RAILWAY BRIDGE, MESTRE-MIRANO ROAD, ITALY.

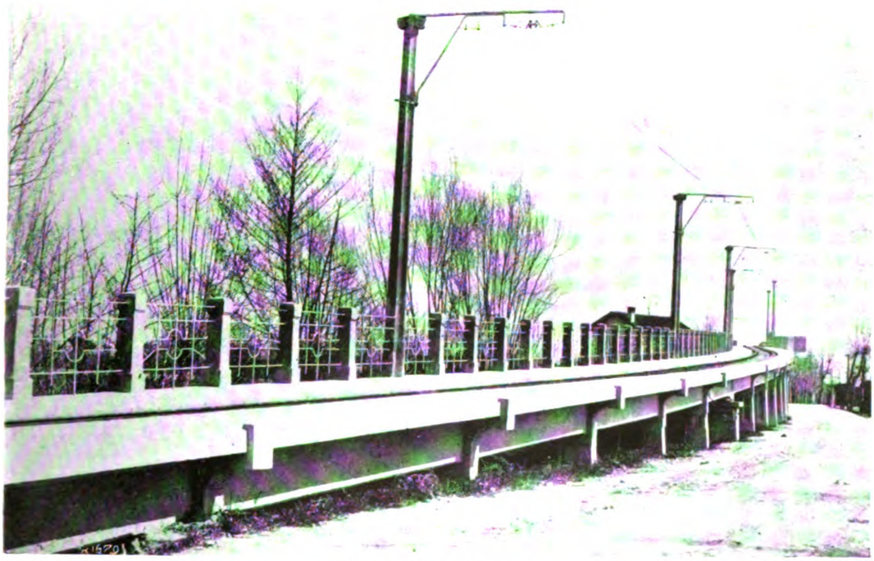


Fig. 7. View of Incline.
REINFORCED CONCRETE TRAMWAY BRIDGE MESTRE, ITALY

5. Stresses due to the trams are increased 25 per cent. to allow for their dynamic action. Factors of safety according to the Italian Ministerial regulations.

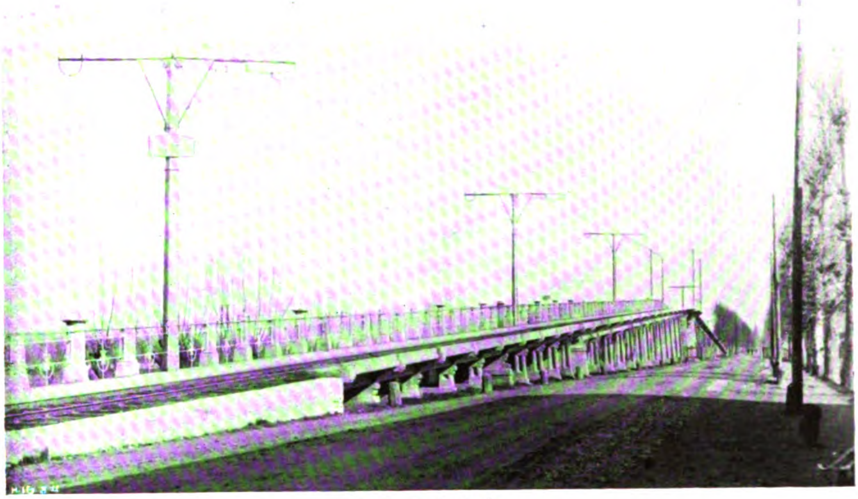


Fig. 8. Long Incline.
Reinforced Concrete Tramway Bridge, Mestre, Italy.

The inclines have a slope of 3 per cent. and are composed of seven longitudinal beams carrying a central continuous slab 7 metres wide and two footpaths 0·75 metre wide, between the parapets; the structure thus composed is borne by piers 6·50 metres apart, each consisting of four columns, the two inner ones being braced together by a St. Andrew's cross (*Fig.* 1). The spacing of the piers was determined by calculation to give a minimum cost.

The structure of each incline is broken at three intermediate points by expansion joints, and sliding bearings are also provided where the roadway rests on the piers of the central span. The expansion joints are constructed very simply by employing twin pairs of columns, reduced in dimen-

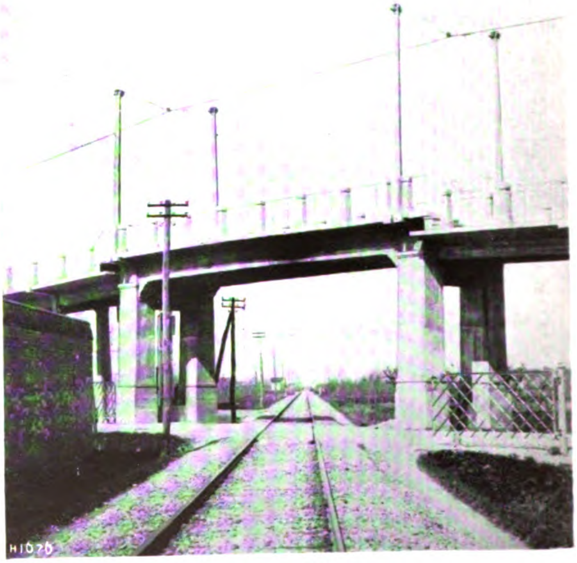


Fig. 9. Central Span.
Reinforced Concrete Tramway Bridge, Mestre, Italy.

sions in the direction of the length of the incline, and having sufficient elasticity to follow variations of length due to changes of temperature. The higher the columns the greater is the space allowed at the expansion joints.

The roadway, 7 metres wide, is for vehicular traffic, and is paved with ordinary macadam, and carries the tramway rails. The footpaths are paved with cement.

The electric overhead wires are supported by reinforced concrete masts on Pasquali's patented system (*Fig.* 2). These have been largely used on other lines, and are employed throughout the 11 kilometres of the Mestre-Mirano line.

Each of the inclines curves to meet the central span, the mean radius of curvature being 100 metres.

The central span is composed of decking similar to that of the inclines, suspended by means of lateral ties from two arched beams of double T-section, united in the upper zone by four cross-beams.

The horizontal thrust of each girder is taken by bundles of round steel bars (56 of 30 mm. in each) set in the corresponding longitudinal beam (*Fig.* 6). The ends of the reinforcing rods are wired to a steel framework, as shown in the figure. Each rod is in three lengths, joined by wired-on sleeves.

The arched girders are attached by a hinged joint at one end, and supported on expansion bearings at the other. These bearings are of the usual type, each with four rollers and upper and lower plates of cast steel. The hinged joints, on the other hand, have the special characteristic of being constructed in reinforced concrete, a suitable longitudinal and transverse reinforcement being employed, together with a concrete richer than in the remainder of the construction, made with a small aggregate. This type of joint has given excellent results.

The structure, therefore, behaves as a bowstring girder with two joints, one of which is free to move horizontally. The girders are, therefore, in theory, not subject to variations of stress in consequence of changes of temperature.

This type of construction was chosen after comparison with many others which might suggest themselves in such a case. More particularly, the remarkable height of the bearings above the ground rendered any form of fixed or semi-fixed arch almost impracticable, as the author has shown from an examination of many structures of this kind, for the stresses to be expected from changes of temperature proved to be more considerable than the stresses due to the live or dead loads.

The piers of the central span are two in number at each end, and consist of massive concrete columns with perimetral steel reinforcement resting on broad octagonal bases with large ribs; the pressure on the soil being thus reduced to 1·3 kg. per sq. metre, which is practically constant throughout the structure.

The other parts of the structure are similar to those of the inclines, except for the cross-beams carrying the roadway, which are fixed in at the lower ends of the ties and have a span of 8·50 metres. They are stiffly reinforced, being only 70 cm. deep at the middle point.

The construction only occupied six months; the three following months were occupied by the setting of the concrete, the removal of the centreing, and the finishing work; so that the bridge was completed by April, 1912.

An unusual difficulty had to be overcome during construction, owing to the railway, traffic on which was heavy at that point and could not be interrupted. It was necessary to support the centreing over a span of 15 metres by means of eight large pitch-pine lattice girders (*Fig.* 4), which had to be erected without stoppage of traffic. Scaffolding and planking were then suspended from these by steel ties. This arrangement proved easy and certain in execution.

The loading tests were of two kinds; static and dynamic. For the first, loading was effected by a layer of gravel of 680 kg. per sq. metre; the deflections obtained were as follows:—

	Total. Mm.	Permanent. Mm.	Elastic. Mm.
North arch	7·3	3·2	4·1
South arch	6·6	2·1	4·5
Incline	1·5	0·0	1·5

The maximum theoretical deflection had been calculated to be 6 mm., the smaller value actually obtained is to be attributed to the concrete mixture employed for the central span being richer than usual, and thus having a modulus of elasticity sensibly superior to that assumed—200,000 kg./cm.^{2}.

The dynamic tests were carried out two weeks later, and were conducted by loading the footpaths with gravel up to 500 kg. per sq. metre, and driving a tram across at its highest speed whilst four-wheeled waggons, each drawn by four oxen, were crossing. Elastic deflections of 1·1, 0·6, and 0·5 mm. were thus obtained, with no measurable permanent deflection.

In consequence of the excellent results of the tests the authorities immediately approved of the structure, and it was declared open to traffic.

The general appearance of the central span and one incline is seen in *Fig.* 3.

Tramway Bridge.—The author has also constructed two other reinforced concrete bridges in the same district, one being for the tramway alone over the Venice-Trieste Railway, the total length being about 350 metres, breadth 4 metres, slope 4 per cent., central span 14·20 metres. The other is quite similar, and is on the Valsugana line from Venice to Trento. It was finished in 1912. These two bridges were designed by the author for the Mestre Tramway Co. They do not present features of such technical interest as the first bridge, and the figures (7, 8 and 9) illustrate them sufficiently.

ROOF TIMBERS, WESTMINSTER HALL.

The Report just issued by Mr. F. Baines, M.V.O., on the Roof Timbers at Westminster Hall is one of great value and importance. In the article we publish below we have taken several extracts from the Report [Cd. 7436].—ED.

A VERY interesting report on the condition of the roof timbers of Westminster Hall, with suggestions for maintaining the stability of the roof, has been prepared by Mr. F. Baines, M.V.O., one of the principal architects in H.M. Office of Works; and, as the roof in question is the finest example of a hammer beam roof in this country, the report is of great importance. The matter contained in the report is also of much value, as the expert knowledge that has been brought to bear on the subject has resulted in the production of many facts which are not generally known to architects and engineers. The report is fully illustrated with drawings and photographs descriptive of the condition of the roof at the present time and the suggestions for reinforcement with steel, and a large amount of labour must have been bestowed on the examination of the structure and the preparation of the report. It is interesting to note that the Hall dates from the year 1097, and the walls remain to the present day. The width between the walls is 67 ft. 6 in., and the original roof is believed to have been constructed with intermediate supports in the form of pillars, but the point is not clearly established. The present roof was apparently decided upon in the year 1394, and practically completed in 1399-1400. Many minor repairs have been effected from time to time and reports have been presented; but it was not until the care of Westminster Hall was assumed by the Ancient Monuments Branch in March, 1912, that anything like a thorough examination was attempted, and the present report is the outcome of this examination. There are thirteen trusses in all, and of these eight have been selected for particular reasons and the causes of decay are stated as follows :—

(*a*) Dry rot.
(*b*) Incipient surface decay.
(*c*) Decay due to the attacks of the *Xestobium tessellatum*.
(*d*) Decay due to the attacks of a smaller Anobiid Beetle.
(*e*) The ravages of the Goat Moth.

Many investigations have been made with a view of finding a remedy in the form of a liquid which would preserve the wood from further decay, but although eighteen different solutions have been considered, they all appear to be either impracticable or ineffective, and no satisfactory conclusion appears to have been arrived at up to the present. Creosote appears to be the only fully effective insecticide known, and even then it would have to be applied in a proper manner, which would necessitate taking down the roof for treatment, and it would further effect the colour of the oak, which it is desirable to avoid.

A detailed examination is given of all the main constructional members in the trusses dealt with, but space will not permit of this part of the report being considered fully. It is sufficient to note that the defects due to decay and twisting are many and serious, and such that collapse is quite likely to appear at an early date if steps are not taken to introduce reinforcement of some kind.

The theoretical development of the hammer beam roof is also given, and the functions of the various members are described, thus enabling the stresses to be fully realised. The question of piecing up the timbers with modern oak is considered, but the method is not advised.

> The cubic content of oak from which the whole of the roof timbers were cut is so great, amounting, as it does, to roughly 40,000 cu. ft. of timber, exclusive of the roof boarding, that, should any very considerable cutting away and reparation be intended, the cost of supplying and fixing the materials would indeed be very large. The conclusion was arrived at that not only would the method suggested be the most economical, but that by it the historical and archæological claims would be given the fullest consideration.
>
> The method is, broadly, as follows:—To maintain the roof in its integrity by a full scheme of steel reinforcement, designed so as to affect the appearance of the structure as little as possible, and to afford adequate support to every one of the members. The particulars of this scheme will be developed later, but its bearing on this portion of the report is that, should some such scheme not be approved, not only will it be impossible to render the roof safe by piecing up the timbers, but it might even be necessary in certain cases to take the whole of some of the trusses down, renewing in their entirety many of the constructional members. It will be realised that the gravest danger would be involved in merely cutting and piecing up many of these defective members, as their whole effectivity is relative to their being complete members in themselves, and not jointed members. To cut and piece up the hammer-beams would be the gravest of constructional errors, should they be called upon to carry unrelieved the present stresses of the roof. Therefore, with some system of steel reinforcement, the whole of the timbers examined up to the present may be so treated that every vestige of the original wood unaffected by decay can be retained, and that only certain portions, such as entirely perished purlins, would have to be wholly renewed.
>
> Before dealing with the question of the proposed steel reinforcement an enquiry had to be made into the stability of the walls of the Hall. This point is most important, inasmuch as the steel reinforcement might be so designed as to exert an outward thrust on these walls. Holes were, therefore, sunk by the external faces of the walls on the east and the west sides to ascertain the nature and depth of the foundations and the character of the sub-soil upon which they rest.
>
> It was found in both cases that the foundations are carried down to a solid bed of alluvial, gravelly sand, which proved to be lower on the east side than on the west by about 6 in. This would naturally be expected, as the river is on that side. The difference is so slight, however, that it need not be considered. The lowest course of the footings of the walls consists of rough boulders of Kentish rag, with good ballast filling between them; the depth of this cannot be ascertained within a few inches.

The information gathered during the investigation was such that, provided the walls are monolithic throughout, there is no reason to fear that they would not be able to withstand any of the dead loads or thrusting stress which they might be called upon to bear.

The reasons for adopting a system of steel reinforcement may be stated briefly as follows:—

(*a*) To overcome the necessity for renewing the great proportion of the main constructional and subsidiary timbers.

(*b*) To strengthen the roof, so that even should the decay in the timbers continue as in the past, there would be no danger of complete collapse such as exists at present.

In all cases, however, where the decay has developed into large cavities and fissures in the wood, the defective timbers will have to be cut and pieced, so as to provide a solid bearing for the reinforcement on each side of the members. This piecing up in oak will have to be done simultaneously with the work of reinforcing the members with steel. Before this can be attempted a carefully designed centre or supporting scaffold will have to be built up from the floor of the Hall to carry fully every member of the trusses treated and also the intervening bays. The approximate weight of this centre for two trusses and one bay will be about 115 tons, and should it have to extend to the ridge of the roof it might possibly weigh from 150 to 170 tons. Should it be found necessary, however, to centre up four trusses and three bays at one time, the weight of the steel in the centering alone would be much greater.

It is proposed to construct this centre of steel members of ordinary commercial sections, and the major portion of it will be erected so that it can be rolled on wheels from one position to another. This will be adopted for that portion which clears the truss under the hammer-beam, and rises about half-way up the arch formed by the two curved struts from the lower ends of the hammer-post to the centre of the great curved rib and collar beam. Above these levels the centre will have to be taken down and rebuilt as its positions are altered, and it may be advisable so to arrange that the upper stages of the centre, where they reach up to support the upper collar and higher portions of the upper principal, together with the ridge, should be constructed of timber erected from the steel centre at the level of the middle of the hammer-post.

The weight to be carried by the steel centre for two trusses, one bay, and portions of two other bays will be approximately 115 tons, made up as follows:—

	Tons.
Approximate weight of two trusses	45
,, ,, one bay	30
,, ,, portion of two other bays	40
	115

Wind pressure, calculated at 20 lb. per ft. super. over the whole roof surface, may increase this by another 60 tons for three bays, giving a total of 175 tons to be carried by the centre in the worst case. Should it be found necessary, however, to centre up at one time four trusses and three bays, this load will be about doubled. The centre, therefore, together with its own weight will be carrying a very heavy load at the base, which the present floor slabs would not sustain safely. I find, however, that some 18 in. to 2 ft. below the slabs is a layer of lime concrete, which rests upon made ground superimposed over Thames mud and blue clay. These sub-soils are not in themselves satisfactory, but they are contained by the great walls of the Hall, which go right down on to good sandy gravel for their foundation. The concrete should therefore, I think, safely carry the weight of the centre and the superimposed load of the truss.

The difficulties of fixing the centre are very great. At Eltham, where a similar but much smaller timber centre has been constructed, the condition of the roof was such as to allow of the lifting of the truss by wedging up under the ends of the main collar beam, where it joins with the principal rafters. In the case of Westminster Hall roof, however, this method is quite impossible, for the joints between the main collar beams and the upper principals and hammer-posts are so bad, and in some instances so much affected by decay, that if any attempt were made to carry and lift the roof at this point many of the trusses would collapse. A further complication arises from the fact that at Westminster Hall the principal rafters are in two sections, and any attempt to carry the roof at the main collar (the foot of the upper principals) would seriously endanger the stability of the lower principals. The question of decay generally applies to almost every other structural point in the truss—namely, to the hammer-beams (the timbers of which are mostly perished at their wall ends and some are also perished at their free ends), to the lower principals, which are perished at their wall ends, and to the purlins, which have in some cases perished throughout their whole length. The steel centre has therefore had to be designed to clip and carry each individual member of the truss freely and by itself at points where the timber is sound. This has added greatly to the difficulty of designing the centre, and will necessitate the greatest care and foresight in actually carrying out the work. The difficulty is one which must be met, and I see no reason why the work should not be safely executed if erectors are employed who have had large experience in dealing with dangerous structures.

A further point which will have to be observed carefully with regard to the centres is that they must retain the trusses absolutely in their present positions. No wedging up or drawing together must be attempted, and each truss must be strictly maintained in its existing vertical plane. Should one of the trusses, when freed from the strut supports of its purlins while the latter are being reinforced, rock either towards the north or south, the gravest danger of the collapse of the adjacent trusses would occur.

As the trusses must not be jacked or lifted up in any way whatsoever, it will be necessary to make provision for drawing together the various sections of the reinforcement in the most careful manner, before letting the truss sink back on to its supports after the reinforcement is fixed. This point is an important one, as it will be seen that unless the steel reinforcement is dead tight and true everywhere on the truss, it will when actually carrying its load deflect under such load, on the removal of the centre, and possibly open many joints in the timber. This difficulty was overcome in part at Eltham by slightly lifting the truss and wedging up, which has taken a proportion of the spring out of the principal rafters, so that the reinforcement will be fixed on the principals in a more favourable situation than the actual position taken up by the latter before the centering was fixed. The deflection due to the load when the reinforced trusses at Eltham are put back on to the walls cannot be so great as the amount of the distortion which existed previously in the roof, and which has been relieved by the wedging up. Although it is intended to reinforce only two trusses at one time and to complete that section of reinforcement throughout, yet to accomplish this the three double ranges of purlins must be reinforced and connected up to the steel reinforcement of the two trusses for three bays. This will mean that two other trusses, one on each side of the two actually reinforced, must be tampered with and indeed freed from the strut supports of the purlins for a time. After which the reinforced purlins must be temporarily affixed to the two unstrengthened adjacent trusses. In the present condition of the roof, this will be a highly dangerous operation unless these trusses, as well as the two trusses dealt with and reinforced, are also centred up and supported in the meantime. It may be deemed advisable, therefore, to arrange to centre up four trusses and three bays in order to reinforce at one time two trusses and three bays only.

In considering the proposed scheme for the steel reinforcement to the trusses, etc., the following main points have to be regarded :—

(1) The steelwork should be so designed as not to prejudice seriously the appearance of the truss and the general amenities of the structure.

(2) The steelwork should in itself be adequate, not only to carry effectually the weight of the trusses, but to support each main member so that it can be pieced up where decayed, rather than entirely removed.

(3) It should be designed so that too great a thrusting stress is not transferred to the walls.

(4) It should, when inserted, fully provide against the possibility of collapse in any of the trusses, should further dangerous decay take place.

The problem would therefore appear to resolve itself into one of adding to the existing timber work an entire truss of steel, which would be able to support the whole of the present roof together with the weight of the steelwork itself, so as to bring the total weight of the strengthened roof to a safe and satisfactory bearing on the walls. The only alternative to this would be to strengthen by individual steel reinforcement each decayed member of the truss, and by inserting plates and bolts to make up the deficiencies in the strength of the pieced-up structure.

If this latter method, however, were carried out, the amenities of the roof could scarcely be considered. A very large proportion of the old timber would have to be taken out, practically amounting to a rebuilding, while the steel straps which would be necessary to bind the work together could not be kept in the background, and would most seriously affect the general appearance of the structure. In addition, the scheme, though very costly, would not be a full and effective means of providing for the safety of the roof in the future, should the decay continue.

This alternative was therefore abandoned at the commencement of the consideration of this problem, and careful thought was given to the question of selecting the best form of steel reinforcing truss, which would efficiently support the roof under the conditions laid down, and would interfere in the least degree with the general appearance of the timbers.

The system suggested above consists of a complete steel truss which follows the outlines of the principal rafters on the top, and the outlines of the great arched rib on the underside, and finishes at the bottom by horizontal members at the level of the wall plate. The truss is braced throughout by a complete system of single triangulation with a few exceptions.

Considerable difficulty was experienced in dealing with the junction of the upper principal rafter, queen post and upper collar. These three members do not meet in a point, and in order to make the error in fixing as small as possible, the steel member which follows the upper collar is placed at the top of the timber, and the vertical steel ties are placed on the outsides of the queen posts, instead of in their centre. This partly overcomes the difficulty, while the heavier reinforcing steel plates on the upper principal rafters are placed so that the secondary stresses may be satisfactorily resisted. In deciding on this form of truss, and on the sections to be employed, very careful consideration has been given to the absolute necessity for doing everything that is possible to keep the steel reinforcement out of sight, and where this could not be done, to construct the steel reinforcement in a simple and unobtrusive form.

It has also been very necessary to give the closest attention to the question of building the reinforcement into position. The consideration of the facilities for the erection of the steel reinforcement on the site is a most important one, as a scheme might well be designed which it would be impossible to carry out without taking down a large proportion of the roof. In the present scheme, however, the work can be executed without unduly interfering with the existing timbers. It will, of course, be necessary to lift down on to the staging some of the members of the roof to allow of the introduction of the steel reinforcement. The most important of these, however, are the collar beams and purlins. With regard to the first, many of the collar beams are in such a dangerous condition that it would be absolutely necessary to lift one of the two timbers of this member out to repair the other, and so one would have to be removed in any case. Even if this were not so, the vast gain to the roof by getting the reinforcement to the main collar-beam out of sigh by inserting it between the two timbers of this member should make this method of erection an acceptable one. As regards the purlins, these are in such an extremely defective and dangerous condition that without some scheme of reinforcement most of them would have to be renewed.

The members, therefore, which it will be necessary to take down in order to insert the reinforcement are not such as could ordinarily be allowed to remain up if the scheme of steel reinforcement were not proceeded with. So much of the roof will be left in position, and, indeed, must actually be retained in position, to allow the steel reinforcement to be applied, that the present proposal does, in effect, demand the retention of the majority of the members of the trusses undisturbed.

In providing for the insertion of this scheme of steelwork, the existing reinforcing timbers and steel tie-rods, etc., can all be removed, leaving the roof in this respect almost entirely as it was originally built.

The difficulties of erection and fixing will be great, and these will only become apparent as the work is proceeded with; they should not prove insuperable, however, if experienced erectors, who have had some knowledge of such exceptional work, are employed in the execution.

The loading calculated includes the total dead load of the roof, together with the wind pressure, which is taken at the small allowance of 25 lb. normal per ft. super. of the roof area, to which has been added about 5 cwt. per ft. of the span of the truss to cover the additional weight of the steel reinforcement in each bay. In the calculations for the steel reinforcement, however, this allowance for wind pressure has been increased. No snow load has been taken in the calculation, as it is unlikely that any serious weight of snow would remain on this roof at such a steep angle. The addition, however, of 6 in. of snow covering the whole of the roof would only increase the stresses approximately to the extent of about 7½ per cent., and the safe stresses allowed for on the whole of the steelwork are taken in the calculation to give a factor of safety of 3¾ generally. Thus the addition of 7½ per cent. to the stresses would leave a very satisfactory margin for the possible future depreciation of the steel by oxidation, etc. This is well within the usual accepted safe stresses on steel.

In selecting suitable sections for the truss members of the steel reinforcement, the limited space available, and the necessity for keeping the steelwork as much out of sight as possible, have been very fully considered. The result is that the steelwork, which includes forged rods, heavy turned pins, large gusset pieces cut to very irregular sizes, etc., is not at all of a simple nature, and in the working out of the details a vast amount of calculation and consideration will have to be given to the designing of the connections. The complicated and costly nature of the steelwork, however, has had to be faced, to meet the difficult and unusual conditions imposed by the problem. Whenever bolts are necessary in the jointing of the steel truss they will have to be of best turned steel.

In order to keep the section of the members which act as struts to neat and unobtrusive proportions, particularly in the case of the principal rafters, it was necessary to calculate the timber as a bracing which would prevent the buckling of the steel plates. Thus these plates on each side of the principal rafters will be bolted together through the thickness of the timber, and every portion of hollow and decayed wood must be made good by new pieces of oak. These must be secured, not by simple butt jointing, but by good scarfing joints, so that the timber itself will hold the steel reinforcing plates rigidly in their relative positions. This condition being attained, the steel alone will then be fully capable of resisting the compression without any further assistance from the timber.

In all the bearings, in order to bring the load well on to the walls and not upon their edges, a steel girder has been introduced, held down by an anchor bolt at the back and bearing upon a cast iron bed-plate, and thus on to the wall.

In order to carry out the erection, which will be a matter of extreme danger and difficulty, the most expeditious manner, as well as the safest, will be to erect it from a travelling steel stage or centre, which has been previously described. On this stage at two levels—namely, just under the hammer-beams and just beneath the main collar beams—close boarded platforms will be fixed, and these would be the two main working stages for getting at the roof. Smaller platforms would be necessary at other places. All additional staging necessary to reach other parts of the roof for taking templates, and for general purposes, could be constructed in steel and timber from these platforms.

In order to get the steelwork made in the manufacturer's yard before delivery, the most careful and accurate full-size templates would have to be taken at the Hall. These would be of an unusual size, and would have to be sent to the manufacturers in order that the steelwork could be fitted to them so that it would fit dead true to its positions when delivered on the site.

For the reinforcement of the purlins it is proposed to use steel joists with a wide top flange, in order that the steel member shall have stiffening in two directions, and thus resist the tendency to sag in the plane of the covering of the roof, which is so obviously an existing defect.

It will be necessary to take down the existing timber purlins (re-using every portion unaffected by decay), and cut them in half for their full length, after which the halves will be bolted to the web of the steel reinforcing purlin girders. The reinforced purlin will then be put back in the same position, and will efficiently support the common rafters without sagging. This operation will necessitate the fixing of temporary purlins to carry the common rafters, as it is undesirable to take down the whole of the latter members if that can be avoided; only such of them as are perished or seriously affected by decay would be removed.

A further important point which will have to be considered will be the necessity for the most accurate fixing of the steelwork throughout the truss. It may even be necessary to tie in the steel reinforcement across the width of the Hall, so as to stress slightly the reinforcement throughout before it is let down upon the walls. When completed, and when the centre is removed, the deflection under its full load should not then be sufficiently serious to cause fracture and opening of the timber joints.

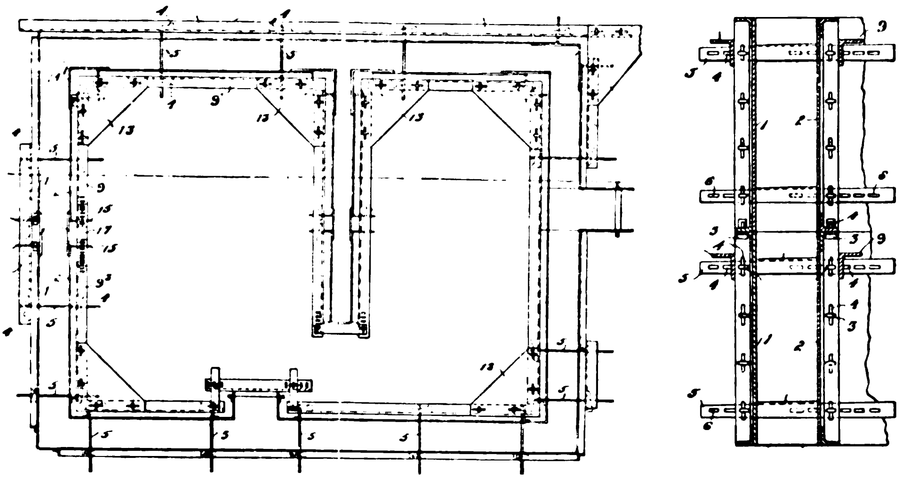
The estimated cost of the work proposed is about £60,000.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. The last article appeared in our issue of April, 1914.—ED.

Forms for Concrete Walls — *No.* 5,046/13. *Blaw Steel Construction Co. Accepted February* 12/14.—The present invention provides improved forms for the construction of concrete walls of varying thickness and length from the same parts, the construction being such that the number of different parts required is reduced to a minimum.

The units from which the form is built up consist of the usual rectangular plates, provided at their edges with out-turned flanges. These units or panels are made preferably in a limited number of standard sizes, and are secured together at the flanges by means of releasable connecting means extending preferably through perforations in the said flanges in the usual manner. In order to secure slight variations in the dimensions of the walls to be built, filler plates are employed which overlap the standard units, and the two sections of the mould joined by the filler plate are rigidly secured in fixed relative position by what may be termed liner bars. These liner bars are secured rigidly to each section of the mould with their ends adjacent, and these ends are secured together by means of splice members which are secured detachably and adjustably to each of the liner bars.



FIGS. 1 & 2. FORMS FOR CONCRETE WALLS.

The opposing sides of the form (*Fig.* 1) are built up of the panels 1—1 and 2—2, provided at their edges with angles secured to the plates constituting the bodies of the panels and having out-turned flanges. The flanges of adjacent panels abut each other, and each are perforated to receive slotted keys 3 (*Fig.* 2), whose slotted portions are engaged by the wedge-shaped members (4), so that adjacent panels are detachably clamped together. The panels are conveniently 24 in. by 24 in., and in connection with these, other panels, 24 in. long but only 12 in. and 6 in. in width, are employed.

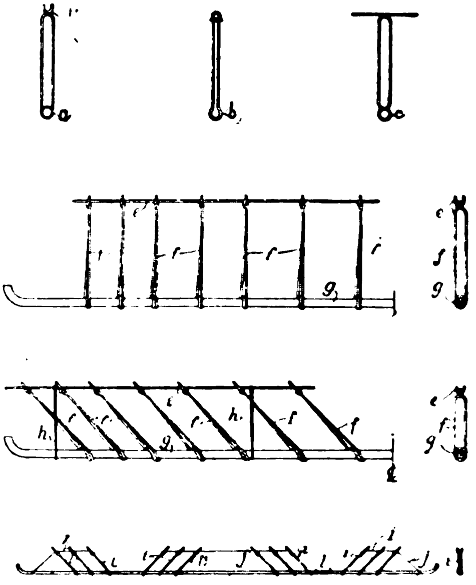
The two opposing sides of the form are held rigidly in their proper relative position by space bars (5). These space bars (5), which are also sometimes known as tie bars, are tapered, in order to permit of their more ready withdrawal from the concrete after it has set, and are each provided in their ends with slots (6) for adjustment in spacing. The keys (3) extend through the slots (6) and through the abutting angles carried by the panels, such keys being secured by wedges (4).

Extending transversely across the plates 2—2 constituting the inner wall of the form are angle liner bars (9). The vertical flanges of these bars (9) are provided with the slots for the passage of the ends of the space bars (5), and the ends of the horizontal flanges of the angles are provided with closely spaced adjusting slots for securing them to a splice plate. These liner bars may be used on the outside mould as well as on the inside mould.

The liner bars also provide a connection between adjacent sections of the mould where a filler plate is interposed between such sections of the mould, in order to secure any desired adjustment as to the length of the mould. Where the connection between adjacent mould sections occurs at the corner, the splice plate (13) is preferably triangular. The two adjacent mould sections at this point are joined by means of the lap filler plate (14^1), so that the relation between the walls may be adjusted to any desired degree of fineness by varying the lap between the filler plate (14^1) and the adjacent walls. The spacing of the adjusting slots at the ends of the liner bars is made slightly greater than the spacing of the slots in the splice plate (13), so that a vernier adjustment may be secured between the liner bars and splice plates. The splice plate (13) is secured to the liner bars (9 and 9^1) by means of slotted keys (3) held by wedges (4). To hold the ends of the panels adjacent the splice plate (13) against movement, relatively short slotted tie bars (15) which can be secured to the filler plates are keyed to the angles of the panels by means of the keys (3) and wedges (4), and extend through the end slots in the liner bars, and are held by wedges. The tie bars (15) may be used in place of space bars (5), the liner bars being in that case held in position to the one mould by the short tie bars.

Where filler plates are required in the straight portions of the mould the liner bars (9 and 9^3) are in alignment, and a rectangular splice (17) is employed for securing the liner bars (9 and 9^3) together, such plate overlapping the ends of the two liner bars. This splice plate (17) is provided with the series of perforations corresponding to the perforations in the splice plate (13).

Steel Truss Reinforcement.—*No.* 4,897/13. *T. B. Cooper and C. E. Holloway. Accepted February* 5/14.—This invention relates to the construction of reinforcing trusses for reinforced concrete structures.



Figs. 1—4. Steel Truss Reinforcement.

Looped or eyed stirrups are strung on the main reinforcement bar, and afterwards forcibly inclined to the required angle; the stirrups thus bind by their loops against the main reinforcement bar, and at their other ends against a bar which is tied by cross ties to the main reinforcement bar.

Three different kinds of reinforcing stirrups (*a*, *b*, and *c*, *Fig.* 1) are suitable for employment in the construction of the trusses. The stirrup (*a*) is looped at one end, and twisted to form a fork (*d*) at the other end. The stirrup (*b*) has a loop at one end and an eye at the other. The stirrup (*c*) has a loop at one end and is twisted at the other end, where it has extensions from the twisted part.

Fig. 2 shows one-half of a truss in process of construction; the stirrups (*f*) shown are of the kind indicated by (*a*), *Fig.* 1. The stirrups are looped at one end, and by the loops they are strung on the tension reinforcement bar (*g*), along which the stirrups are slid to their required locations.

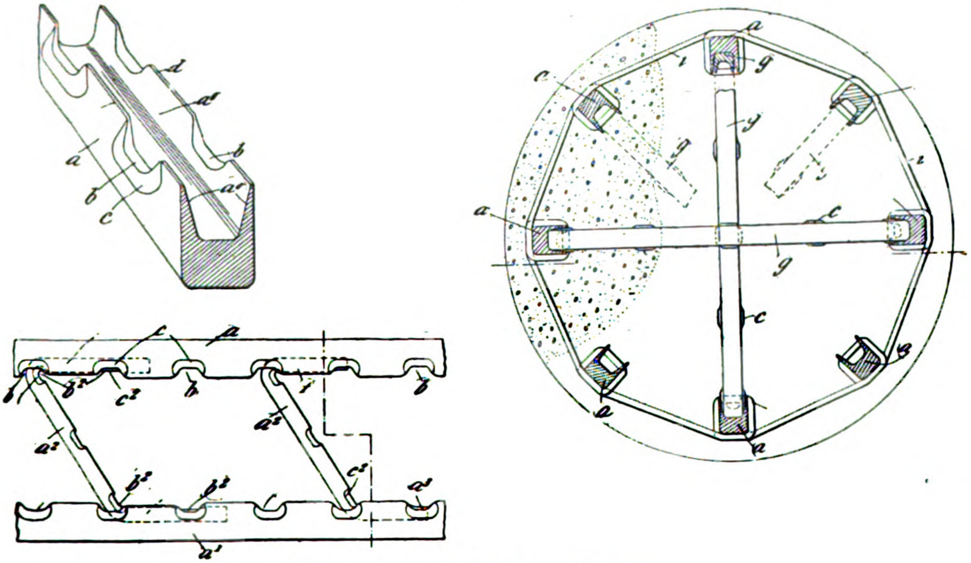
In the forks at the other ends of the stirrups is laid a bar (*e*). By pressure exerted by hand or otherwise on a bar (*e*) all the stirrups (*f*) of the set are forced into a slanting or inclined position, as seen at *Fig.* 3. The bars (*e*) and (*g*) are then tied together by ties (*h*). By the tendency of the stirrups to rebound, the loops become jammed tight on the main reinforcement bar (*g*), and the forks bear tightly against the bar (*e*).

Instead of being sloped together through the agency of the bar (*e*), the stirrups may be sloped singly or otherwise, by hand or by other means, the bars (*e*) and (*g*) having been previously tied together by ties (*h*).

In the truss shown at *Fig.* 4 the stirrups (*i*) are arranged in groups, and are held at their correct final inclination by wires (*j*), by which the stirrups in the several groups are tied together and, in some cases, to the main reinforcement bar (*l*) also. This method is particularly suitable for slabs, especially where the main reinforcement is continuous over supports. In all cases the ends of the stirrup bars may be left long enough to be used for attaching additional reinforcement or for providing extra anchorage.

Metal Reinforcing Bars.—*No.* 5,238/13. *R. Hopewell. Accepted February* 25/14.—This invention relates to interlocking metal bars for ferro-concrete, provided with a dovetail or similarly sectioned slot or groove, with cut-away side portions, to permit of the insertion into the said dovetail groove of the ends of other strut or tie or tension rod members, so as to form an interlocked junction.

According to the present invention, the bars of this type are so constructed that when the ends of the transverse or diagonal bars are inserted into the main bars they can be held firmly in position by clinching certain parts of the bars. Moreover, the bars are so rolled that the strength and the sectional area of the bar is maintained throughout its length, and when bars of similar construction are used these are interlocked with the main bars so as to prevent movement in any direction.



Figs 1—3. Metal Reinforcing Bars.

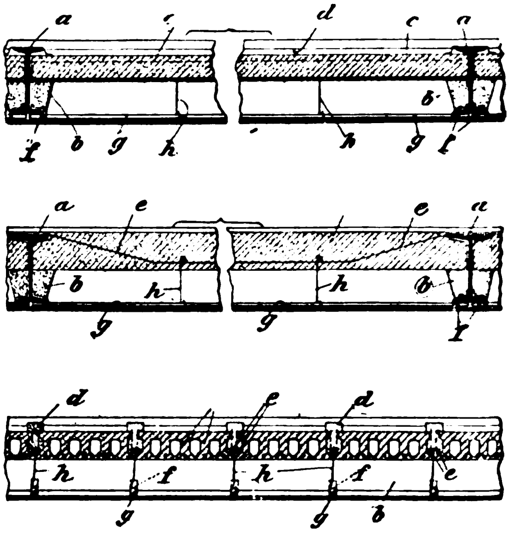
The metal bar (*a*) is formed or rolled in the form shown in *Fig.* 1. It is made of approximately U or other suitable shape, with an open groove on one side forming a channel, the inner sides (a^{o}) of such channel being inclined inwardly and downwardly, so that the mouth of the channel is wider than the bottom. The sides of the channel are provided on opposite sides with gaps or openings (*b*), preferably at uniform intervals along the length of the bar. Where these gaps (*b*) occur the metal is thickened on the outside of the bar, so as to form an outer protuberance (*c*) surrounding the gap, and thus leave a thinner strip of metal (*d*) standing up between the gaps (*b*) on each side of the channel. In rolling the bars, the metal squeezed out to form the gaps (*b*) can be utilised to form the protuberances (*c*). By this construction an otherwise weak part of the bar, where the gaps occur, is strengthened so that the strength of the bar and its sectional area is uniform throughout its length.

To build up a ferro-concrete beam structure, such as shown in *Fig.* 2, the two main bars (*a*, a^1) are laid with their channels opposite each other. The bar (a^2) of the next size smaller, is then employed for the diagonal tension rods. The ends (a^3) of each of these bars (a^2) are then bent at a suitable angle, a sufficient length being bent over to permit the gaps (b^2) of the bar (a^2) to coincide with the adjoining gaps (*b*) of the main bars (*a*). When such bar has been placed in position, the metal (*d*) intervening between the gaps is then clinched together, as shown at (*f*), causing the protuberances (c^2) around the gaps (b^2) of the inner bar (a^2) to enter the gaps (*b*) of the outer bars (*a*), thus firmly holding the main bars and the diagonal bar in an interlocked condition. Round or other shaped rods may be used instead of the shaped bars. (a^2).

For pillar construction upright bars (*a*, *Fig.* 3) are arranged in pairs opposite each other. Cross bars (*g*) are employed, these bars (*g*) being arranged between four upright bars, as shown, and also between the other bars arranged at a different level and staggered with respect to each other. These cross bars are clinched and further secured together by a metal rod or wire (*i*) which is bent round the upright metal bars (*a*) in succession, such rod or wire (*i*) forming a convolution encircling the upright bar (*a*) and the bend of the cross bar (*g*) where the gaps meet, and then passes on to the next upright bar (*a*), which it encircles, and then on to the next upright bar, and so on.

Reinforced Floors and Ceilings.—*No.* 1,708/13. *A. Hammer. Accepted January* 15/14.—This invention relates to ventilated reinforced concrete floors stretched between I-girders, and resting on supporting blocks which are seated on the lower flange of the I-girders, and consists in the arrangement of ventilated flat concrete sections keyed together at the intervening joints by means of reinforced fillings, which at the same time carry hangers for the lower ceiling and form top ridges for supporting floor boards.

Upon the I-girders (*a*) are seated the blocks (*b*) for ready-cast ventilated sections (*c*). The blocks (*b*) may be cast direct on to the girder or prepared as blocks and then cemented in position. The ventilated sections (*c*) are reinforced in any suitable manner, and they have grooves along the adjacent sides, so that, when the sections are placed in position, the grooves will form channels to be filled with concrete for permanently connecting the sections and for producing top ridges (*d*) for supporting floor boards, and which are reinforced by a pair of rods (*e*). The ends of the reinforcing rods (*e*) are bent so as to hook over the girders (*a*).



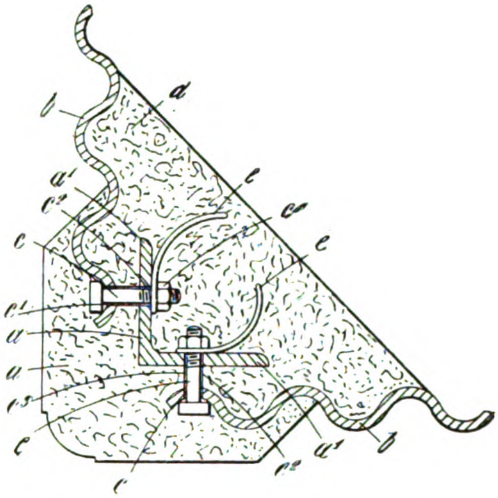
Figs. 1—3. Reinforced Floors and Ceilings.

In the blocks (*b*) are provided straps (*f*) for retaining bars (*g*), which serve for carrying the lower ceiling portion. These bars are preferably rods, which are prevented from sagging by means of hangers or suspension hooks (*h*), secured with their upper ends to the reinforcing bars (*e*).

Beams or sections of this kind can be manufactured for sale to suit various requirements, and they can be carted to the site for immediate use.

Securing Corrugated Sheeting to Supports.—*No.* 15,948/13. *G. W. Malcolm. Accepted January* 8/14. This invention relates to securing corrugated sheeting to supports for building purposes, and particularly to sheeting of this kind which is composed of asbestos or cement, or a mixture of these or similar materials, the chief object being to enable a tight and neat joint tc be made between the adjacent or contiguous edges of the sheets and the structure to which they are applied.

According to this invention, the corners are formed of moulded concrete or ferro-concrete, so that the ends of the corrugated sheets and the member to which they are applied are firmly bedded therein. The sheets will readily unite with the concrete and form a neat and secure joint.



Securing Corrugated Sheeting to Supports.

Both flanges (a^1) of the upright iron support at the corner of the structure are drilled at intervals to receive suitable securing bolts (*c*). Corresponding holes (c^1) are formed in the two corrugated sheets (*b*) in proximity to the edges, and the securing bolts are passed through these holes and the holes (c^2) in the flanges (a^1) of the angle iron uprights (*a*). The bolts (*c*), however, are not intended to bring the asbestos sheets (*b*) against the flanges (a^1), but are adjusted so that these members are spaced apart. The object of leaving a space between the asbestos sheets (*b*) and the angle iron support (*a*) is to allow of free communication between both sides, so that the concrete *d*, when applied to the joint forms one solid mass around the several parts. Distance pieces (c^3) may be placed on the securing bolts (*c*), so that the nuts (c^4) thereon may be tightened up and the parts firmly held the desired distance apart.

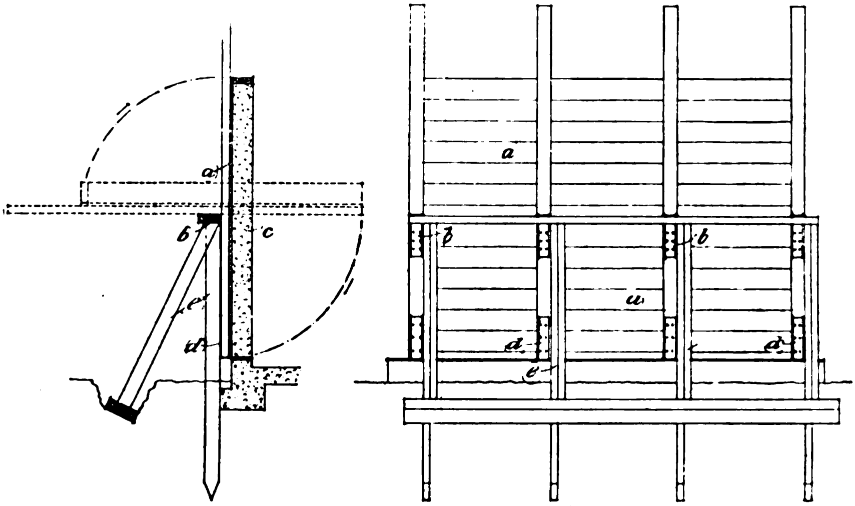
In order to increase the grip of the angle iron (*a*) or other member in the concrete (*d*) a number of hooks (*e*) may be applied to the bolts (*c*), so as to project from the flanges of the angle iron or other supporting member. When the corrugated sheets (*b*) and angle iron support (*a*) have been secured together in this manner they are ready to receive the concrete (*d*). This latter is applied by arranging suitable moulding boards around the angle formed by the adjacent edges of the corrugated sheets and filling the hollow mould thus formed with the concrete.

Building with Concrete.—*No.* 12,592/13. *T. L. Watson. Accepted February* 5/14.—This invention consists in the formation of the concrete walls of a building, with the necessary door and window openings, upon the horizontal platforms (*a*) hinged at or near the middle by hinges (*b*), so that when the concrete (*c*) which has been spread upon the platform (*a*) has set, the walls—that is, the platform (*a*) containing the concrete (*c*)—can be rotated or turned over, as shown, on its hinges (*b*) into the upright position which they are to occupy in the building. The walls are then wedged up with slate or other material above the foundation and damp-proof course of the building, which has been laid in the usual manner.

The iron knees (*d*) supporting the concrete (*c*) and secured to the strengthening bars and boarding of the platforms are then withdrawn, and the platforms (*a*) with the supports (*e*) removed. Grooves or rebates having been left in the concrete where the side and end walls meet, these are filled in from above with liquid cement, thus making the entire building monolithic. The building may then be finished externally with rough cast, cement, or other material.

The platforms (*a*) are constructed of the floor and roof boarding, strengthened by the roof spars of the building and the joisting of the floors, so that there is practically no loss of material.

In the case of buildings of several storeys, each storey may be constructed separately by the same method, or two storeys may be formed together by one operation. When it is desired to have a building faced with stone, either wholly or partly, the platform may be laid with thin ashlar having the necessary header or bonding stones. The concrete is then filled in above the ashlar to the required thickness, recesses being left for string courses or other architectural features.



Figs. 1 & 3. Building with Concrete.

THE USE OF CONCRETE IN COAL MINES.

In a report issued some time ago, by the Bureau of Mines, U.S.A. ("Bulletin No. 56") some interesting tests were described. A short résumé of these tests is so far as they particularly apply to concrete and reinforced concrete is given below. Our Illustrations have been taken from the "Bulletin" in question.—ED.

THE adaptability of reinforced concrete to all classes of work is almost daily becoming more evident, and another instance is afforded by the use of this material in the experimental mine which has been formed on the property of the Pittsburg Coal Co., near Bruceton, Pa., for the purpose of conducting experiments as to the phenomena of coal-dust explosions. These tests are being conducted under the auspices of the Bureau of Mines (Joseph A. Holmes, Director) by Messrs. George S. Rice, L. A. Jones, J. K. Clement, and W. L. Egg, and the object of the experimental work is to obtain information which will enable a solution to be arrived at for the prevention of mine explosions, and it was considered necessary to conduct the tests in a mine rather than in a surface gallery. The results and effects of the first series of tests are published in Bulletin No. 56, published by the Bureau of Mines, and they form very interesting reading matter. When considering the effect produced by the explosions on the reinforced concrete work it is necessary to bear in mind the nature and power of the damaging forces which are clearly set forth in this publication.

When the source of heat—for example, the flame from a blown-out shot—is introduced into a cloud of coal-dust combustion takes place between the particles of dust and the oxygen of the air. If the quantity of heat transferred to the dust-cloud is relatively small the combustion may proceed only in the immediate vicinity of the heating agent. When the conditions are favourable, however, the flame is propagated through the dust-cloud with rapidly increasing velocity and rising pressure. A true dust explosion then results, and the velocity of the flame rises rapidly to over 2,000 ft. per second and great pressures are produced. It is not intended to go into the details of all the experiments in this article, as they are somewhat outside the scope of this journal; but the above notes should be sufficient to indicate the nature of the work.

The mine was commenced in December, 1910, and the first tests were begun in October, 1911. The underground passages consist of two main parallel entries a little more than 700 ft. long each 9 ft. wide, with a 41-ft. pillar of coal between them. There are cross passages between the two main passages at intervals of about 200 ft.

REINFORCED CONCRETE LINING.

The main entry is provided with an arched portal of heavily reinforced concrete (*Figs.* 1 and 2), with retaining wall, wing walls, and buttresses built "en masse"; the walls are carried down to the solid formation, and the buttresses to a limestone 3½ ft. below the coal.

The reinforcement consists of ½-in., ¾-in., and 1-in. round rods of mild steel placed vertically, diagonally and horizontally. The vertical rods are set in drill holes in the limestone. The stresses considered were (1) those due to forces directed outward from the mine, and (2) a bursting pressure acting at right angles to the axis of the entry or tunnel. The wing walls were also designed as retaining walls for the roof shale and dirt cover over the arching of the tunnel. Some of the reinforcement at one stage of construction is shown in *Fig* 3. The arrangement at the entrance provides for the future addition of a counterweighted door, sliding vertically in grooves, for use in special experiments requiring a perfectly quiet atmosphere.

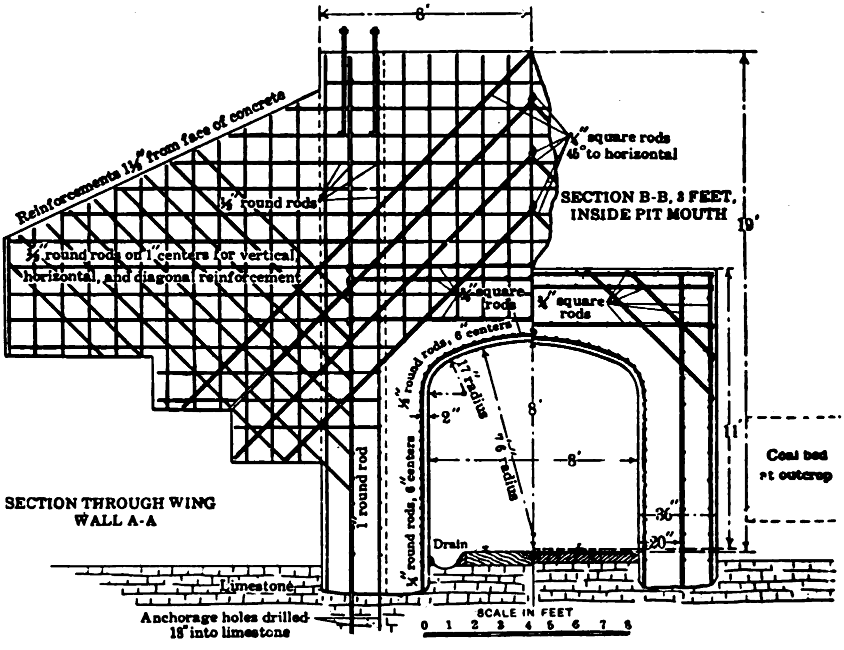

8'
Reinforcements 1½" from face of concrete
¼" square rods 45° to horizontal
SECTION B-B, 8 FEET, INSIDE PIT MOUTH
19'
½" round rods
¾" round rods on 1' centers for vertical, horizontal, and diagonal reinforcement
¾" square rods
¼" square rods
¾" round rods, 6" centers
17" radius
2"
8'
76" radius
8'
11'
Coal bed at outcrop
36"
20"
Drain
1" round rod
¾" round rods, 6" centers
SECTION THROUGH WING WALL A-A
Limestone
Anchorage holes drilled 18" into limestone
SCALE IN FEET
0 1 2 3 4 5 6 7 8

Fig. 1. Cross section of reinforced concrete portal of experimental mine.
THE USE OF CONCRETE IN COAL MINES.

It was intended that a similar entrance should be placed at the mouth of the air course. Owing to the lack of funds this was not completed for the tests of the first series, but has since been erected. The air course entrance was not intended to be used for explosion tests during the first series. A reinforced concrete portal is provided for the diagonal heading similar to that of the main entrance except that the walls are not so heavy, the heading being smaller in cross section.

It was necessary to line the outer parts of the entries on account of the poor roof; indeed this had to be supported by heavy timber while the entries were being driven. It was manifest that timber for lining would not be satisfactory in explosion tests, as the timber would be likely to be blown out. As the best material for lining seemed to be reinforced concrete, a type of lining was adopted similar to that so extensively used in the Béthune mines, Pas de Calais district, France, as designed by J. Lombois, principal engineer.* The concrete on the side walls is 7 in. to 9 in. thick, and thicker in places where

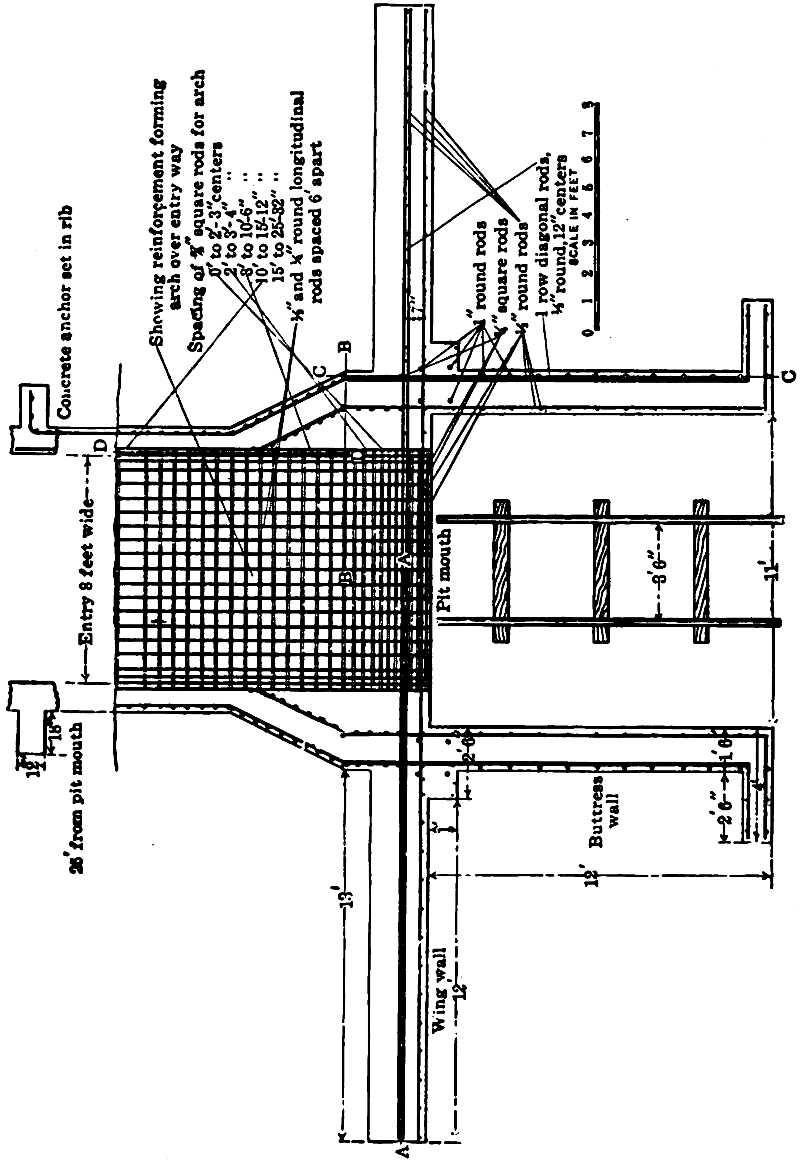


Fig. 2. Plan of reinforced concrete portal of experimental mine.
The Use of Concrete in Coal Mines.

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* Lombois, J., Revêtement en béton armé des bouvettes et des bures aux mines de Béthune: Bull. Soc. Ind. Min., ser. 4, vol. 6, 1907, pp. 195-205.

irregularities in the natural walls required the filling. The arch is made 7 in. or more thick. As it was necessary to have the lining strong, the concrete mixture was made relatively rich, being 1 part Portland cement to 2 parts sand and 4 parts gravel.

The reinforcing bars of the arch are $\frac{3}{4}$-in. square steel rods, placed 6 in. apart in that part of the entry close to the mouth and 32 in. apart farther in. The arches were made in two halves, each half extending from the foundation to the centre of the crown, where they were joined together by a bolt passing through a loop in the end of each half arch. The horizontal reinforcement consists of $\frac{1}{4}$-in. rods placed 12 in. apart and wired to the arch rods at the intersections. The concrete lining was put in place over forms of collapsible type which could be moved from point to point as the work advanced.

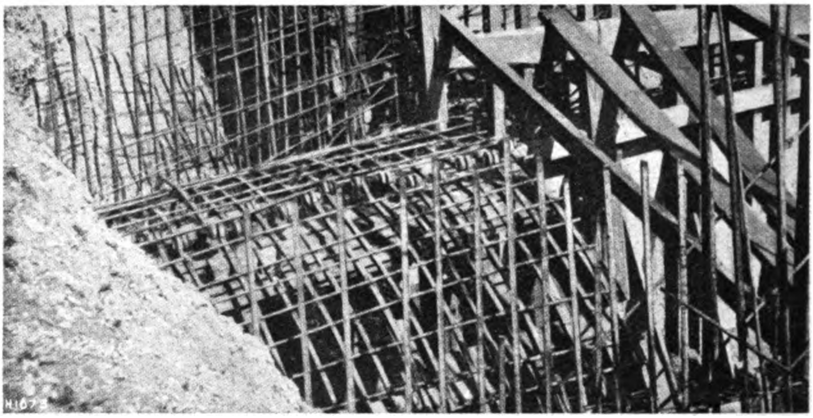


Fig. 3. Reinforcement of portal.
The Use of Concrete in Coal Mines.

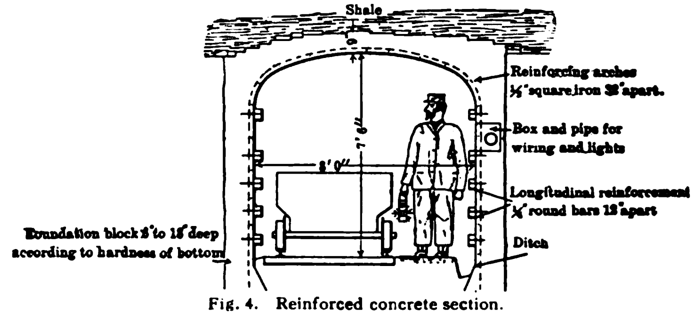

Shale
Reinforcing arches
¾" square iron 32" apart.
Box and pipe for
wiring and lights
7' 6"
8' 0"
Longitudinal reinforcement
¼" round bars 12" apart
Foundation block 8" to 18" deep
according to hardness of bottom
Ditch

Fig. 4. Reinforced concrete section.
The Use of Concrete in Coal Mines.

While the concreting material of the lining was being placed, bolts were inserted for the support of five shelves on each side to be used in coal-dust explosion experiments. There was also laid behind the wall a 4-in. steel pipe in which were placed electrical cables, a 2-in. pipe for a compressed-air line, and a 2-in. water main with hydrant boxes every 100 ft. The arched lining, which is finished smooth, is 8 ft. wide in the clear, and 7 ft. 6 in. high from the top of the track ties to the arch; near the entrance the roof has a slight rise and the floor descends, so that the arch is 8 ft. high at the portal. The diagonal heading or gallery is smaller, being 6 ft. 4 in. wide and 6 ft. 4 in. high (*Fig.* 5).

In constructing the lining in the outer part of the main entry and in the diagonal heading or gallery the preliminary timbering had to be left in place above the arching as the roof was too weak to allow its removal. Adjacent to the portals the arches were constructed in the open; they were afterwards covered with dirt, which was filled in to the top of the retaining walls. During the first series of experiments the concreting was extended into the main entry, making its total length 169 ft.; the entire diagonal heading, 198 ft. long, was lined, and in the air course there was a lining from a point 20 ft. outby the connection with the diagonal heading or gallery to a point 65 ft. inby the junction. At the wide space at the junction, the roof had been supported with railroad rails which were left in to supplement the strength of the reinforced lining.

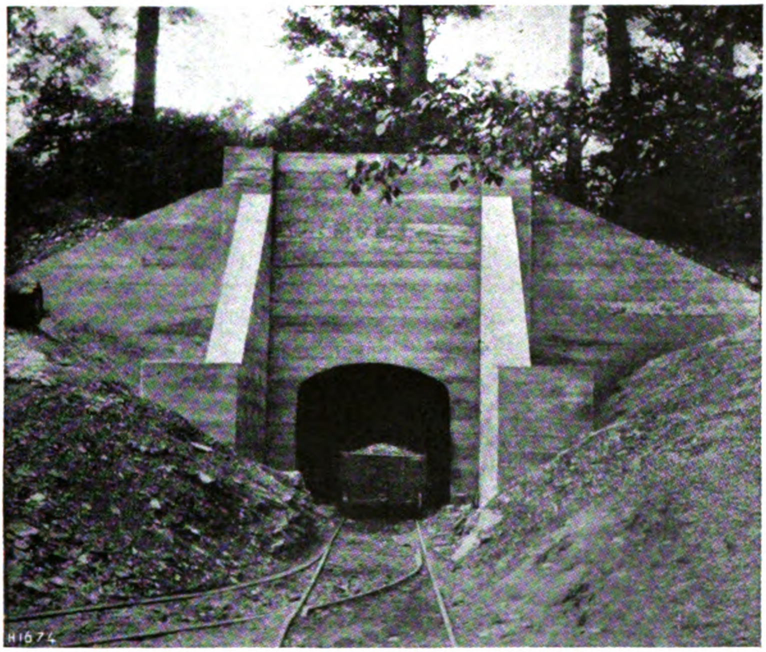


Fig. 5 Finished portal.
THE USE OF CONCRETE IN COAL MINES.

The reinforcement was placed in the concrete arch to help support the roof. It was thought that the weight of the roof, together with its resistance to shear, could be overcome by the upward pressure of an explosion. This proved not to be true; the arch and roof lifted, causing the arch rods to break through the facing. In future construction the arch reinforcement will be placed

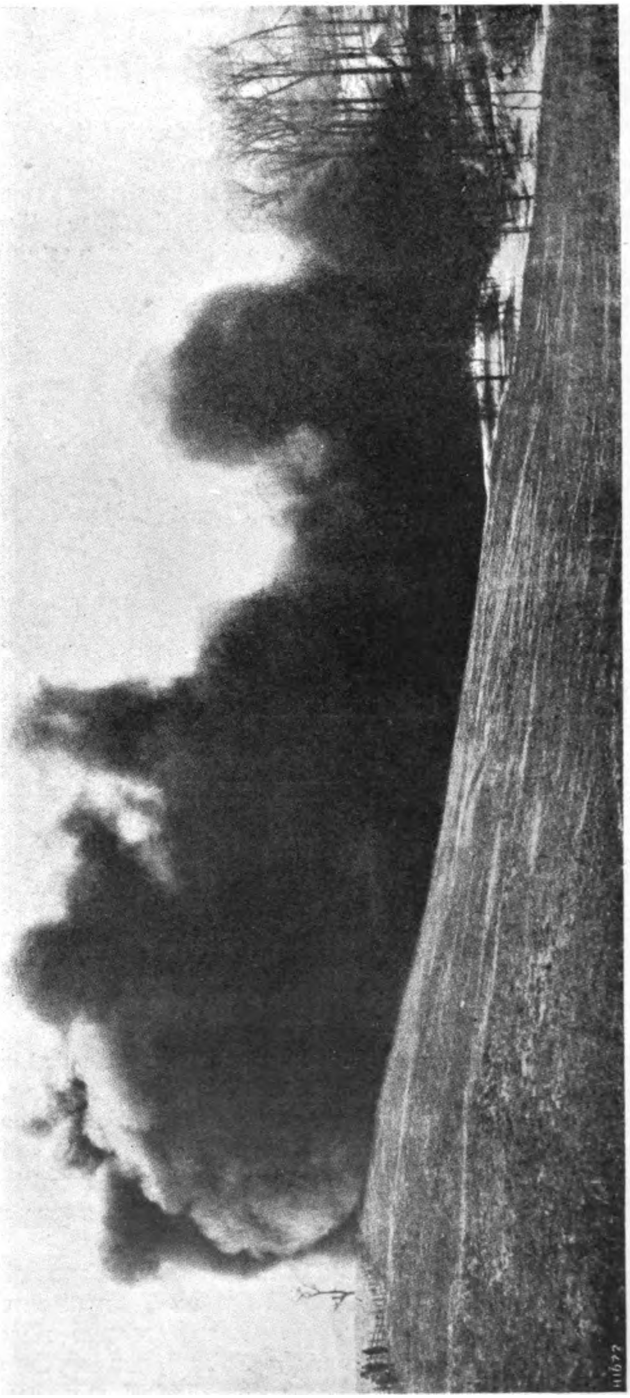


Fig. 6. Explosion issuing from portal test 15.

THE USE OF CONCRETE IN COAL MINES.

farther from the face of the concrete, and the arch thickened to resist the force of an explosion.

Some idea of the explosion caused during the tests is afforded by the illustration in Fig. 6, which shows the issue from the portal. The explosion caused by the first test resulted in the concrete roof being lifted together with the upper part of the corner pier, and it was found that the reinforced concrete lining was not quite strong enough in itself to prevent rupture when the explosion reached the detonating stage.

During the second test the lateral pressure of the main explosive wave was demonstrated by the concrete arching in one place being lifted nearly 13 in., and by the lift of the arching in the diagonal heading which for its entire length of over 200 ft. was lifted bodily, the reinforcing rods being pulled through the concrete. This lift was about 12 in., judging from one piece of reinforcement which was doubled back on itself. Not only did the strength of the lining itself have to be overcome, but also the weight and resistance to shearing of 6 ft. to 12 ft. of natural strata, shale and clay overlying the arching. Fifteen tests in all were conducted, and with the exception of the damage caused by the two cases above mentioned the reinforced concrete appears to have suffered no injury. The concrete work was repaired, and some adjustments made on the strength of the knowledge gained during the first two tests, and the fact that the material has since proved satisfactory indicates its suitability for work of this nature.

RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

THE ARCHITECT AND STRUCTURAL ENGINEERING.

By WILLIAM E. A BROWN, A.R.I.B.A.

The following is an abstract of a Paper read at the Forty-ninth Ordinary General Meeting of the Concrete Institute.

Referring to Mr. Cyril Cocking's Paper on "Calculations for Steel-framed Buildings from the Draughtsman's Standpoint," read before the Institute some weeks ago, the author stated that he did not consider that the position of the architect in relation to steel-frame buildings he is called upon to design and carry out had been sufficiently considered.

Structural engineering includes, not only steelwork used in buildings, but also all forms of construction, whether in brick, stone, timber, or concrete, and in designing buildings and other structures the architect is called upon, not only to exercise his artistic ability, but also so to plan and arrange the various materials to carry safely, in addition to their own weight, all superimposed loads and external forces, so that the whole may remain perfectly stable.

The Architect to Determine Positions of all Steelwork.

It is the architect, and the architect alone, who should determine the positions of all main girders, stanchions, and supports. In many buildings it is impossible to proceed with the design until these positions are determined. In some cases it is the roof which is the determining factor in planning a building—whether the spans shall run from north to south or east to west.

The author said he had buildings in mind now that could be designed in three or four different ways, all depending on the arrangement of the girders and roof trusses—to mention one, a large garage with offices over, and, of course, as few stanchions as possible on the ground floor. Before he could proceed far with the sketch plans to submit to his clients he had to consider the construction of the building, and finally decided on putting in five lattice girders of about 50 ft. span, one boom in the flat roof and the other in the floor of the first floor. In the course of the discussion on Mr. Cocking's paper several of the speakers implied that architects are generally not qualified to deal with these matters, but delegate the work to some one else. How is it possible for an architect to prepare a design and submit plans to his client for approval without knowing and showing where stanchions and piers, etc., are to come? To do so would be courting trouble.

Necessary Information to be given to Engineers when obtaining Estimates.

A good deal of stress has been laid on the question whether the steelwork should be designed, and quantities taken out by a consulting engineer, before being sent out to the constructional firms for estimates, or whether these firms should be allowed to do the calculations themselves.

For contracts involving a large amount of steelwork of a complicated nature a consulting engineer should be appointed by the architect, but there are many smaller works where this is not necessary, nor would the outlay on the building work warrant the expense incurred. It is quite satisfactory, given certain conditions laid down, for the architect to send the drawings to several firms of engineers, and let them make their own calculations and quantities; but to enable the various contractors to estimate on the same basis, the following information must be given to each :—

1. Plans of all floors showing the lines of all main girders and the positions of stanchions and columns; also a section or sections and outline elevations must be given. It is not always possible at the stage when estimates are invited to supply ½-in. scale sections through the external walls, etc., as was suggested by Mr. Cocking.
2. The loads that each floor has to carry and whether live or total loads.
3. Whether British or foreign steel is to be used, and whether the L.C.C. regulations under the General Powers Act, 1909, are to be complied with. If not, the stresses should be specified that are to be worked to.
4. Whether price is to include for hoisting and fixing, or only for steelwork delivered to site.
5. If it is to be delivered unpainted, painted, or oiled, and if painted with what materials, and that all scale and rust must first be removed.
6. Workmanship, whether connections are to be riveted or bolted, and if the latter whether ordinary bolts will be allowed.
7. Whether the price is to include 10 per cent. profit for the builders or only 2½ per cent cash discount. My own practice is to state the latter.

Floor Loads and Loading.

There is a diversity of opinion as to whether the dead loads and superloads on a floor should be kept separate in making the calculations, or whether a load, to include the dead weight of the floor itself, should be taken.

One must, of course, take into consideration the point loads which often occur from partitions, etc. This is often neglected by competing firms of engineers, but some of the concrete partition blocks on the market weigh a considerable amount, and one is often surprised when the weight is calculated out.

Another matter is the central loading on girders carrying walls with openings and narrow piers between. Some engineers assume that the loads are evenly distributed over the span through the brickwork below the window-sills. If the sills are very high up, this may be so; but in many cases the sills are only 12 in. or 18 in. above the girder, and the loading in such a case should be considered as a point load, or as a distributed load over a length of the girder equal to the width of the pier.

In calculating the loads on stanchions, etc., the author said he did not take advantage of the reductions allowed by the 1909 Act.

Connections, Workmanship, and Supervision.

The connections and workmanship are very important matters to be considered, and they do not always receive the attention that should be given to them. Of what use is it to have a strong joist or stanchion, if the cleats under the joist, or the joints in the stanchion, are not properly designed, or, if the design is correct, the connections themselves are badly made? How often does one find, when checking the carrying out of work that the connections between girders and stanchions, calculated to provide a fixed end for the stanchion, are such as to be practically useless to attain that object.

The number of rivets in cleats carrying the ends of joists should also be carefully checked. The 1909 Act says that rivets shall be used in all cases where reasonably practicable, but there are a very large number of buildings to which this Act does not apply. The author said he quite agreed with Mr. Cocking that all steelwork should be designed in accordance with the provisions of the 1909 Act. The conditions for bolted work should be amplified in the Act, the only requirement now being that the bolt shall extend through the nut and the latter be secured so as to avoid the risk of becoming loose.

Dead bearings should always be provided or else riveted connections. If neither of these is practicable, as in connecting large roof trusses together on the site, then driving-fit bolts with plain shanks right through all the plates, the holes being concentric, should be put in. The ordinary ¾-in. bolt is quite good enough for bolting when it is not called upon to take shear.

By "dead bearings" the author meant that in the case of one joist being trimmed into another it must either rest on the bottom flange of the main joist or have a cleat under, riveted on, or with one edge resting on the bottom flange, or else tapered packing-pieces must be inserted between the lower flanges of the joists, so that the load is transferred direct, and not by means of a bolted connection, which must drop slightly when the load is applied.

Regarding the question of riveting, why are engineering firms so adverse to riveting on the site and also to drilling holes on the job? Time after time holes are in the wrong positions, and they have to be redrilled *in situ*. Any holes in awkward positions or in cleats, etc., that have to be fixed out of square should have the holes drilled on the site, but the firms' representatives fail to see the economy of it.

With regard to riveting, it is now the custom at the works to dispense with hand riveting, and to do the work cold by pneumatic pressure. This is, no doubt, more expeditious and economical, but is not so good as the older method.

Another important point, and one that is not always attended to, is that all holes through two or more thicknesses of metal should exactly coincide. If they do not coincide, how can the rivets or bolts take a proper bearing and transmit the loads from one to the other?

Filler joists in concrete floors should be bolted or cleated, at least every third joist, to the main beams. It is becoming a common practice to place the small filler joists on a concrete haunching resting on the bottom flange of the main girder and not tied in in any way to the girder. This method of construction should be condemned, as there is little or no adhesion between the haunch and the girder, and not very much between the floor slab and the haunch, as the latter is made first and sets hard before the floor slab is cast. Continuous angle stringers riveted to the web of the main beam for the fillers to rest on are preferable. This facilitates erection and the fillers can be bolted to the stringer.

Square bevelled washers should always be put on the flanges of joists when using bolts, and care taken that they are the right way round.

The connection at the joint in the length of a stanchion should be carefully made. The sections should be milled to bear evenly on each other, and the fishplates and angles should be riveted. To make sure of getting a proper seating between the two stanchions, the holes in the upper member should be drilled when the latter is in position.

The walls sometimes actually take some of the weight off the stanchions where the latter are built in, but steelwork should be erected to carry the loads put upon it, and one should not depend on outside support for making good any deficiency in design or workmanship.

There are, of course, cases in which one can legitimately reckon on the brickwork helping the steelwork.

Large gusset plates should not be allowed, unless properly stiffened to prevent buckling. It is good practice to encase the whole of the stanchion base right up to the floor-line with concrete. This prevents rusting, and it also holds the foot of the stanchion firmly in position. The putting of stone templates under stanchions is not to be advocated. There is a difficulty in bedding both the template and stanchion, and if the latter has to be grouted in the stone might as well be absent.

There is some difference of opinion whether the top cleat connecting a beam to a stanchion should be riveted to the stanchion at the works or be sent loose and fixed on the job. The former is not very practicable, as it would be very difficult to get the girder in position, and if sufficient clearance is allowed for this to be done then the value of the connection is materially reduced.

Girders supporting walls as well as main floor girders, if they are formed of two or more plain I-beams side by side, should have plates riveted on top and bottom.

There is just one point in connection with the London Building Act worthy of mention, and that is Section 56 (1), which says: "Every bressummer, whether of wood or metal, shall have a bearing in the direction of its length of 4 in. at least at each end, upon a sufficient pier of brick or stone, or upon a timber or iron story post fixed on a solid foundation, in addition to its bearing upon any party wall or external wall; and the district surveyor shall have power in his discretion to require that every bressummer shall have such other story posts, iron columns, stanchions, or piers of brick or stone or corbels, as may be sufficient to carry the superstructure, and the ends of such bressummer, if of wood, shall not be placed nearer to the centre line of the party walls than 4 in."

When the end of a bressummer is supported entirely by a stanchion built into an external or party wall, the requirement under Section 56 is unnecessary.

With regard to the protection of steelwork in buildings, where the steel is cased in concrete there is no necessity for paint—in fact, it is better not to paint it. All scale and rust should, however, be removed, and a good coat of cement wash is an advantage.

Steelwork in walls should be either cement-washed or painted. Exposed steel should, of course, be painted. The first coat of paint on all work, whether wood or steel, is of the utmost importance, but seldom receives proper attention.

REINFORCED CONCRETE.

This is an excellent method of construction, but very careful and constant supervision is necessary, or something may go wrong.

The author said that in calculating the sizes for steel joists embedded in concrete his practice is to let the steel carry the load as an independent beam, but taking the depth of the beam anything up to $\frac{1}{20}$ of the span, limiting the stress to $7\frac{1}{2}$ tons per sq. in. This is quite enough, as often these small joists, such as 3 in. by $1\frac{1}{2}$ in. and $4\frac{3}{4}$ in. by $1\frac{3}{4}$ in., are of foreign make.

He also had a preference for joists with 3-in. flanges over those with $1\frac{1}{2}$ in. and $1\frac{3}{4}$ in. flanges, for the reason that the concrete, which forms a slab between the steel joists, has a much better bearing on the joist. When the concrete is formed of broken brick or ballast, the aggregate is not often broken up as small as one would wish, and therefore the concrete is not filled in solid around the steel joist. The narrower joists also are often badly distorted in handling, and get put into position all bent without a proper seating at the ends.

The author uttered a warning against using breeze for floors. There is a very great danger of expansion, and he knew of several cases where this had occurred and pushed walls several inches out of upright, and even when the wall was rebuilt it happened again. There is also a corrosive action between the concrete and steel which in time may endanger the stability of the floor.

With regard to shear in reinforced concrete slabs and beams, it is not wise to calculate for the concrete taking any part of the shear, although the R.I.B.A. regulations and those proposed by the L.C.C. give 60 lb. per sq. in. as the allowable shear stress.

Expanded metal is an excellent form of reinforcement for slabs, and binds the whole of the concrete together.

In large beams and pillars there is often a difficulty in getting the reinforcement into the correct positions, and also in having the rods properly surrounded with concrete. Another important item to see to is that all of the rods, where they pass in connecting beams and pillars together, are surrounded with concrete. It is a difficult matter sometimes to do this, and considerable skill is required in arranging the rods in positions such as have been mentioned. As far as possible, the reinforcement for all beams and pillars should be assembled on the ground and the rods securely wired together to keep them in their correct positions before being placed in the forms.

It is also very important that all forms should be properly cleaned out before any concrete is put in, and the best way of doing this is by water and a hose-pipe.

CONCLUSION.

In concluding, the lecturer said these were only a few of the details that come within the purview of the architect, and the modern architect has to be a man of many parts, a jack-of-all-trades—a bricklayer, mason, carpenter, joiner, plumber and painter, always an artist, often a lawyer, and last, but not least, a structural engineer.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

CONCRETE BLOCKS IN THE NEW ELECTRIC POWER STATION, PORT TALBOT.

THE new electric power station just completed on the docks at Port Talbot is an interesting example of concrete block construction. It consists of an engine house, 51 ft. by 42 ft., boiler house, 51 ft. by 42 ft., economiser house, 63 ft. by 34 ft., with a height in the main building of 40 ft. to the ridge.

A steel skeleton was erected, the stanchions of which were placed upon substantial concrete foundations. Between the foundations reinforced concrete beams were constructed to carry the intervening wall panels, as, owing to the site available for the building being newly-made ground, its bearing power was negligible.

ELECTRIC POWER STATION AT PORT TALBOT BUILT OF CONCRETE BLOCKS.

The wall panels were 4½ in. thick, constructed of hollow concrete blocks, grooved and tongued. Owing to the extreme exposure of the position it was thought advisable to face the blocks with neat cement.

In every third joint a strip of 2½ in. Exmet brickwork reinforcement was embedded, and the resultant wall—although only 4½ in. thick—is one of extreme rigidity.

The buildings were designed and carried out under the superintendence of the

Resident Engineer of the Docks, Mr. Wm. Cleaver, M.Inst.C.E.

The type of machine used for the manufacture of the blocks (supplied by Mr. R. H. Baumgarten, of 8, Manor Park, Lewisham, S.E.) admitted of the facing being done as the blocks were made, and therefore thoroughly incorporated with the body of the block.

The concrete work was carried out by the "Ideal Cottage Builders, Ltd.," 36, Gracechurch Street, E.C., who specialise in this kind of work.

COAL AND WATER RESERVOIR FOR THE MARSEILLES GAS WORKS.

THE necessity of storing a large quantity of coal has led the Marseilles Gas Company to adopt the method of storing coal under water to avoid oxidation and the loss of volatile constituents. It has, therefore, had a first reservoir, of gross capacity of 4,500 cu. metres, constructed in reinforced concrete by M. Magnier, contractor, Marseilles, from the plans of Messrs. Considère, Pelnard, and Caquot, engineers, of Paris.

The reservoir consists of a cylindrical tank, 10 metres high and 25 metres outside diameter, of concrete reinforced as described below. The vertical wall rests on a base of mass concrete, covered by a reinforced floor, which is monolithic with the wall. The upper part of the tank has horizontal reinforcement, the section of which corresponds with the total internal stresses.

The reservoir contains a mixture of coal and water. The actual density of coal is 1,250 kg. per cube metre, whilst its apparent density is 900—that is, the volume of voids amounts to $\frac{1250-900}{1250}=28$ per cent. When the coal is submerged there is thus in a cu. metre 900 kg. of coal plus 280 kg. of water, so that the total weight per cu. metre of the mixture is about 1,200 kg.

The water exerts its full hydrostatic pressure against the walls. Coal, having a density greater than that of water, exerts a thrust against the wall equal to that which a filling of density 250 kg. per cu. metre would exert.

The thrust of such a filling is known to be proportional to its depth above the point considered, and to depend on the co-efficient of friction of the filling. For coal the thrust has been taken as one-quarter of the vertical load, and this co-efficient has been considered to be retained in water.

As the voids amount, as has been shown, to 28 per cent., the cu. metre of coal

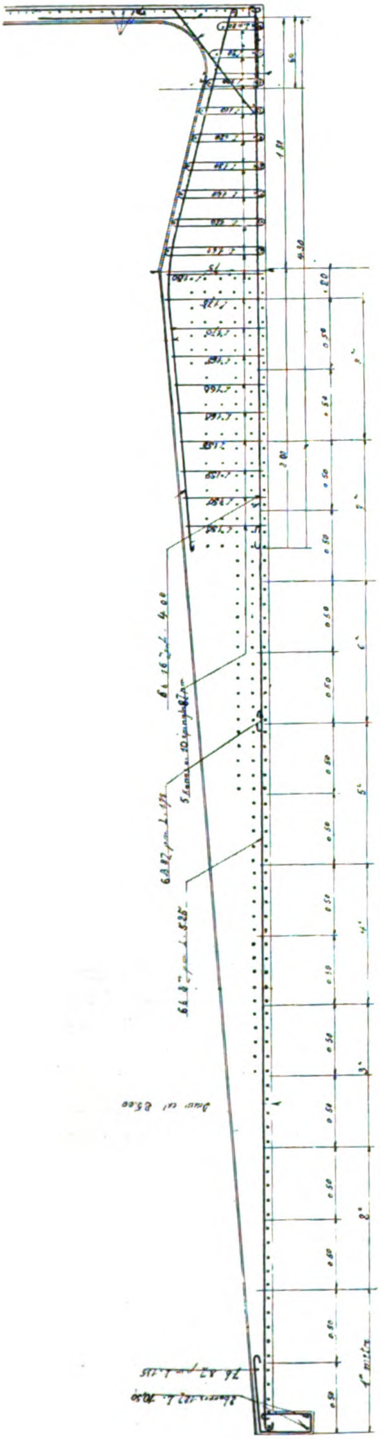


Fig. 1. Vertical Section of Wall.

REINFORCED CONCRETE COAL AND WATER RESERVOIR FOR THE MARSEILLES GAS CO.

weighs, in water $(1{,}250 - 1{,}000) \times 0{\cdot}72 = 180$ kg., so that at a distance h below the surface the thrust of the coal against the walls is $\frac{180h}{4} = 45h$. The thrust due to water is $1{,}000h$.

The reinforcement has, therefore, been computed as if the tank had to contain a liquid of density 1,045. The computation of the steel reinforcement at each level, the steel being stressed to 12 kg./mm^{e}. is too elementary to require reproduction here. It suffices to mention that, instead of arranging the rods in horizontal hoops, built up of several portions, they are united in sections of 12 metres length to form spirals. The number of spirals and the diameter of the rods vary continuously with the stresses.

Should the stresses increase until the steel reinforcement is stressed to 12 kg./mm^{e}. the diameter of the tank would increase, at least in the upper portion of the high tank, but at the base the diameter of the tank could only increase if separation from the floor took place producing a crack which would damage the structure. In theory the diameter might increase by 12 mm., which would correspond with a gaping fissure of 6 mm. wide.

In practice, in reservoirs of small and medium diameter, cracks are avoided by reinforcing the walls with vertical rods which are prolonged into the floor, but it follows that the hoops placed in the lower part of the wall, which should, properly, have the maximum section, are enclosed in a mass of concrete which is prevented from expanding. They are, therefore, stressed much below 12 kg./mm^{e}., and are thus very inefficiently utilised.

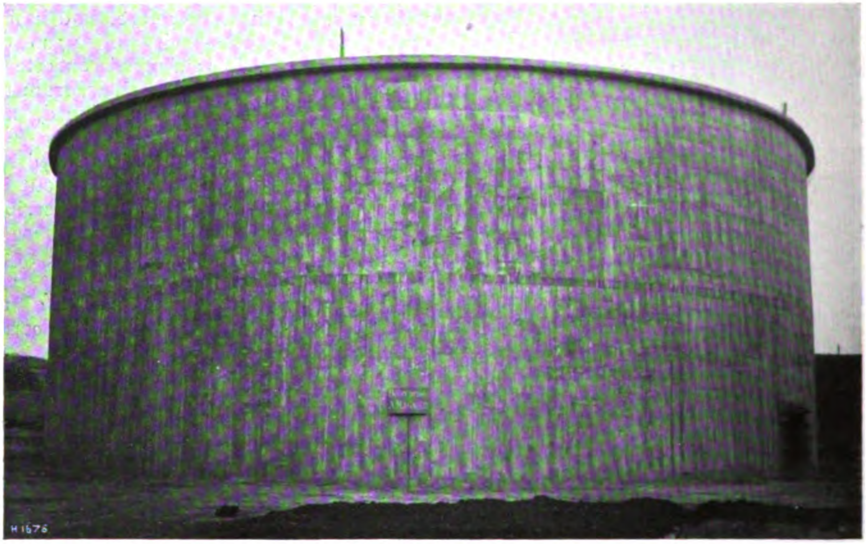


Fig. 2. View of Finished Reservoir.
REINFORCED CONCRETE COAL AND WATER RESERVOIR FOR THE MARSEILLES GAS CO.

The following construction was, therefore, adopted:—

It is assumed that the diameter of the tank may, without ill effects, increase by 10 or 12 mm. as above at heights of 2 metres or more above the floor, and that the wall may bend slightly in the lower zone to adapt itself to the circumference of the floor, which is practically fixed. Each vertical strip of the lower zone has been regarded as a panel fixed at its two extremities, and it has been reinforced with vertical rods allowing it to withstand flexion. The thrust of these elements of the lower zone is then transferred to a reinforced belt 2·50 metres above the floor and to the floor itself, which is reinforced with radial rods prolonged sufficiently beyond the wall; the weight of water on this portion of the floor is then sufficient for friction on the foundation to resist the drag of the wall.

The diagram (*Fig.* 1) shows a vertical section of the wall.

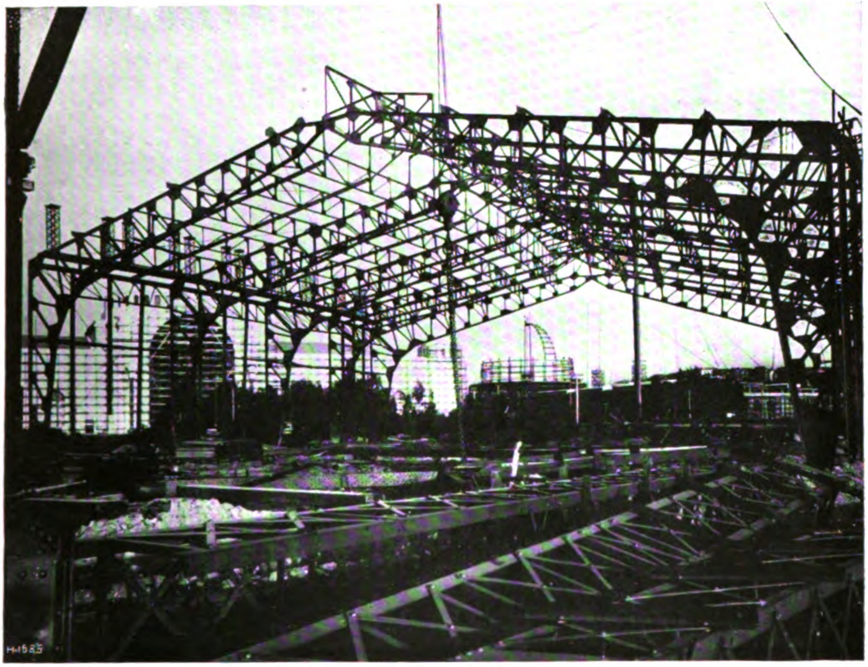
The floor is also provided with rectangular reinforcement to prevent the localisation of fissures and to give the floor a certain flexibility, allowing it to yield without ill effects to the small differences of level inevitably produced by settling under load.

For the removal of coal an opening 2 by 1·50 metres in size has been made in the lower part of the tank to receive a door weighing 3,000 kg., bolted to watertight flanges on its concrete frame. Water is run out by two valves 150 mm. in diameter.

The tests were very satisfactory and were confirmed when the tank was put into service.

STEEL CONSTRUCTION IN THE PALACE OF FINE ARTS AT THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION.

THE accompanying reproduction of a photograph shows one of the steel arches of the Palace of Fine Arts of the Panama-Pacific International Exposition to be held in San Francisco in 1915. As the building will house the art treasures of the world it must be of absolutely fire-proof construction, and for this reason steel was used.



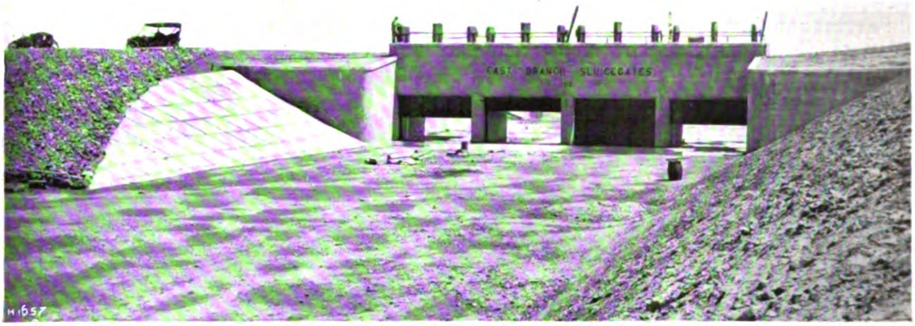
Steel Arch Construction—Palace of Fine Arts.
PANAMA-PACIFIC INTERNATIONAL EXPOSITION.

The plan of the building is that of an arc of a circle, 950 ft. long and 135 ft., the area being 205,000 sq. ft. The walls are 40 ft. high and the ridge of the building 56 ft. high.

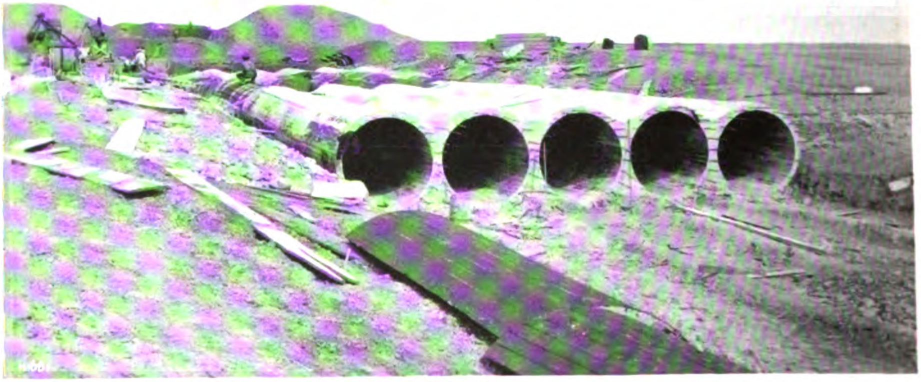
The construction consists of a steel frame supporting a roof of skylights and concrete slabs. The exterior walls are finished in Travertine. The trusses consist of three hinged arches—an unusual form of construction—and are 36 ft. on centres and have a span of 131 ft. Underneath the floor a steel tie connects the hinged supports of the trusses and resists the thrust of the arches. The trusses are inter-connected by means of light bracing trusses, which in turn support I-beam purlins on which the roof slabs and skylights rest.

The steel arches are supported on cast steel hinged bases, which rest on the timber grillages of the piles; pile foundations having been provided to carry the weight of the walls and roof of the building.

The under floor of the building is of timber construction, consisting of shiplap on sleepers laid directly on the ground. The weight of one complete typical arch is 25 tons.



Concrete Sluice Gates.

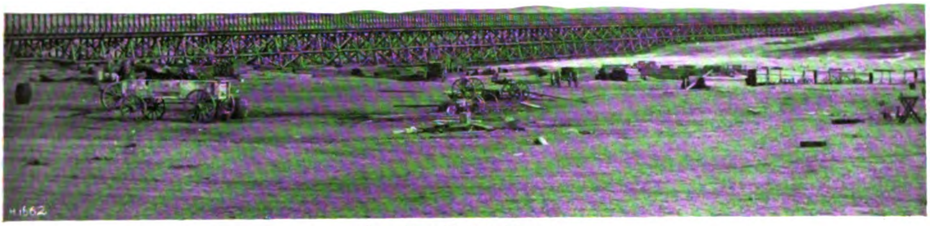


Reinforced Concrete Syphon.

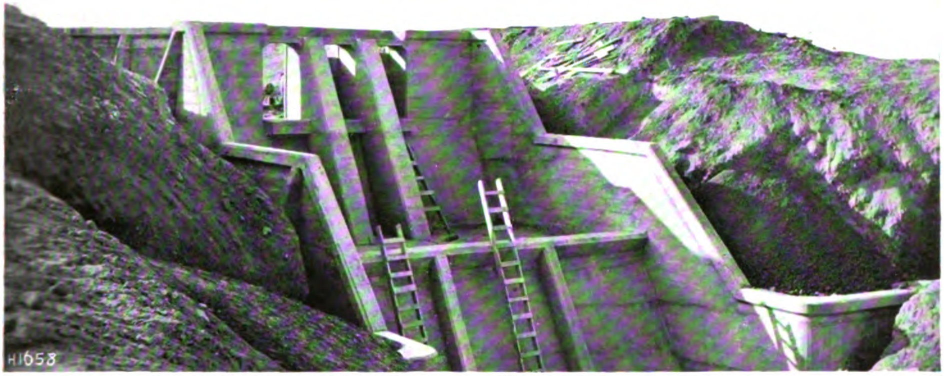
CONCRETE STRUCTURES ON THE IRRIGATION SYSTEM AT CALGARY, ALBERTA.

THE Department of Natural Resources of the Canadian Pacific Railway are carrying out a scheme of irrigation for South Alberta, and we give a few particulars below of the concrete work in connection with the scheme.

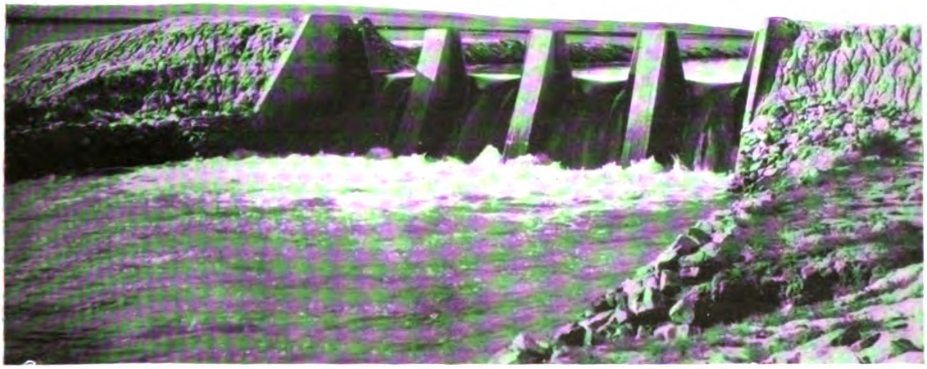
Roughly speaking, perhaps two-thirds of the various structures built are timber structures, and these consist of thousands of large and small headgates, drops, flumes,



Crawling Valley Flume.



Concrete Drop on North Branch Canal.



Concrete Weir.
CONCRETE STRUCTURES ON THE IRRIGATION SYSTEM AT CALGARY, ALBERTA.

highway bridges and culverts, syphons, branch gate, etc. The concrete structures in the main are of similar design to the timber structures, their chief advantage lying in their durability. The bulk of these small structures contains from ten to three hundred cu. yds. of concrete, and their design is peculiar in that they consist to a great extent of exceedingly thin slabs of concrete, heavily reinforced with steel. The quantities in miscellaneous structures amount to approximately 24,000 cu. yds. of concrete. These structures are scattered at intervals all along the canals in the eastern and western sections of the irrigation block, and the quantities given are exclusive of the Horseshoe Bend Dam at Bassano, the Brooks Aqueduct, and the intake to the western section canal system, structures so large and important as to warrant individual mention. The photographs shown will give a good general idea of the type of small structures constructed, and, therefore, only a brief description of the larger ones mentioned above is here given.

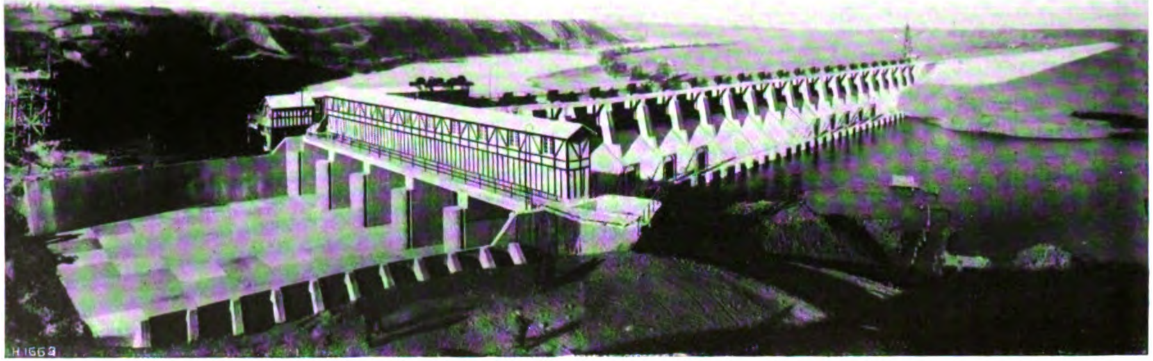
Horseshoe Bend Dam at Bassano.—This structure is a diversion dam built across the Bow River at the above point and diverts 3,800 cu. ft. of water per second into the main channel of the eastern section canal system, whence same is fed to the 2,600 miles of canals and ditches which water the 440,000 acres of irrigable land in this section.

The spillway portion of this dam is of the hollow type known as an "Ambursen Dam," and is 720 ft. long between abutments, with its crest 35 ft. above low water level in the river. The crest is at the same elevation as the sill of the headgates admitting water to the main canal, and twenty large steel gates set on top of the spillway crest hold the water up 11 ft. higher, thus allowing a depth of 11 ft. to pass into the main canal when its headgates are opened. Provision has been made for the spillway to pass water over these twenty gates up to a maximum of 100,000 cu. ft. per second, or "second feet," as this is generally termed. The headgate structure is connected to the spillway at right angles to same, and at its eastern end, and the western abutment of the spillway is connected with an eastern dam 7,000 ft. in length and with a maximum height of 45 ft. This dam extends over a low flat on the west side of the river, and, together with the spillway in the river bed, raises the water to the desired height. The upstream face of this dam is heavily paved with concrete slabs, there being a total of 17,000 cu. yds. of concrete in same. Quantities in the spillway and headgate structures, which were built separately to the earthen dam, are 42,000 cu. yds. of concrete and 2,750,000 lb. of reinforcing steel. Power is developed by turbines in the spillway for raising the gates, lighting, heating, etc., and the bulk of the hoisting and other machinery is housed in the structures which appear in the photographs enclosed on top of the structure.

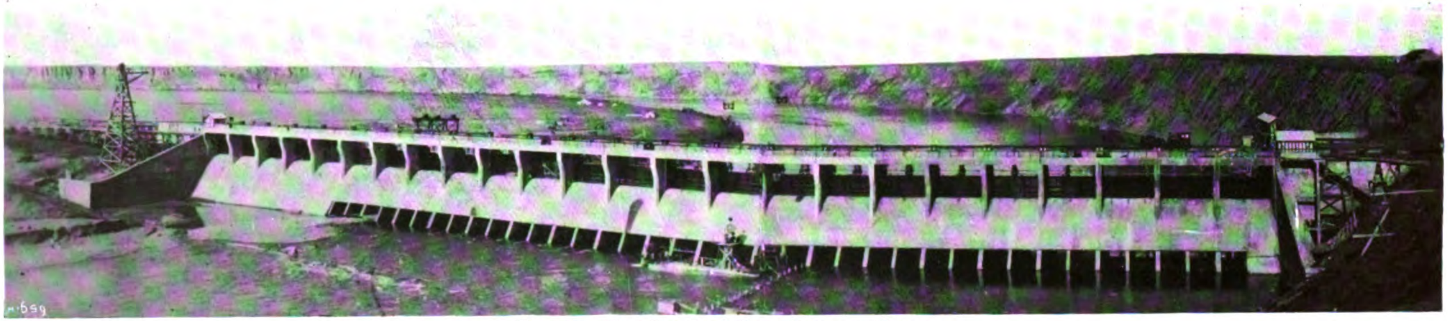
The Brooks Aqueduct.—This structure is not yet completed, and no photographs are available. The aqueduct will carry water for the irrigation of 118,000 acres across a wide valley, and is 10,500 ft. in length with a maximum height of 54 ft. and a sectional area of 129 sq. ft. At the east end the flume is converted into a syphon and crosses under the main line of the Canadian Pacific Railway, thence rising to grade and spilling into a large earth canal of 44 ft. bed width, 2 to 1 side slopes, and a depth of 7·7 ft. of water.

After much calculating and experimenting a unique design was decided upon and the flume is now under construction in the form of a suspended reinforced concrete shell 5 in. in thickness with a section following the elastic curve or hydrostatic catenary. The substructure is of the multi-arched form with spans varying from 30 to 100 ft. The quantities in this flume when finished will run slightly over 25,000 cu. yds. of concrete and 2,000,000 lb. of steel.

Western Section Intake and Weir.—Reinforced concrete headgates have been completed on the Bow River at the intake to the main canal of the western section, near the City of Calgary, and a weir across the river immediately below this intake is nearing completion. The intake is a heavy structure with four 18 ft. 6 in. steel gates, and the weir consists of one movable dam of the bear trap type, 150 ft. in length and twenty-three openings of the stop log type, each 20 ft. clear, and a considerable quantity of earthen embankment. The quantities in this weir approximate 8,000 cu. yds. of concrete, and the chief trouble in construction lay in the placing of foundations, owing to the exceedingly swift current of the river.



General View, Horseshoe Bend Dam, Bassano, Alberta.



Elevation, Horsehoe Bend Dam, Bassano, Alberta.

CONCRETE STRUCTURES ON THE IRRIGATION SYSTEM AT CALGARY, ALBERTA.

The total mileage of canals in the block is 4,000, and the total irrigable acreage is 750,000. The irrigation block lies immediately to the east of the City of Calgary and is 140 miles east and west by 40 miles north and south. All water for irrigation is diverted from the Bow River, which heads in the Rocky Mountains to the west. The average annual precipitation in the district is 15 in.

We are indebted to Mr. A. S. Dawson, Chief Engineer of the Canadian Pacific Railway Company, for our particulars and photographs.

CONCRETE BLOCK SCHOOL BUILDINGS.

THE employment of concrete for school buildings has been discussed in earlier numbers of this journal. It is, therefore, interesting to be able to show in our Frontispiece a photograph of some Government schools erected at Vagterbek, Hungary. The schools are built of "Winget" concrete blocks by the Magyar Winget r.t. Budapest.

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MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

***The Summer School of Town Planning** (August 3rd to 15th).*—In August the first course of lectures in Town Planning, to be held in the University of London, will take place. A summer school, extending over the first two weeks of August, has been arranged for. There will be some twenty-five lectures by the leading authorities. The lectures will be given in the new School of Architecture at University College. The syllabus of the lectures and all further particulars may be obtained on application to Mr. J. S. Rathbone, Joint Hon. Secretary, Fitzalan House, Finchley, N.

Fire Preventive and Fire Service Work.—The meetings of the International Fire Service Council's Executive, which took place in London last month, and which were presided over by Commandant Meier, Chief Officer of the Amsterdam Fire Brigade, President of the Council, and supported by the two Vice-Presidents, Mr. Edwin O. Sachs, F.R.S.Ed. (London), and Major Westphalen, Chief Officer Hamburg Fire Brigade, have been principally occupied with the International Fire Dictionary, which is to be published in three languages, and contain the three equivalents of 5,000 technical terms relating to fire prevention and fire service work.

They have also been occupied in the arrangements for a large International Congress to be held at Copenhagen in 1915.

A report of the resolutions arrived at and the general proceedings will be issued later, but it should be immediately mentioned that the International Fire Service Council were well received in this metropolis, His Majesty's Government having extended courtesies and hospitality to the members, and likewise the London County Council and the British Fire Prevention Committee.

It has also been very flattering to the Council to receive a message of encouragement from His Majesty the King wishing the meeting every success.

International Engineering Congress, 1915.—Among the general subjects to be treated before the International Engineering Congress, to be held at San Francisco, California, September 20th to 25th, 1915, probably the one having the broadest interest is that of Materials of Engineering Construction, which enters into all phases of engineering activity. The list of topics which will be treated in this section is as follows:—(1) Timber; (2) Preservative Treatment of Timber; (3) Substitutes for Timber in Engineering Construction; (4) Brick in Engineering Structures; (5) Clay Products in Engineering Structures; (6) Probable and Presumptive Life of Concrete Structures made from Modern Cements; (7) Aggregates for Concrete; (8) Slag Cement; (9) Waterproof Concrete; (10) Cements containing Additions of Finely Ground Foreign Material; (11) Economics of the World's Supply of Iron; (12) The Life of Iron and Steel Structures; (13) The Employment of Special Steel in Engineering Construction; (14) The Place of Copper in the Present Engineering Field, and the Economics of the World's Supply Thereof; (15) Alloys and their Use in Engineering Construction; (16) Aluminium in Engineering Construction; (17) The Influence of the Testing of Materials upon Advances in the Designing of Engineering Structures and Machines; (18) Cement Testing; (19) Testing of Metals; (20) Testing of Full-sized Members; (21) Proof Testing of Structures. The papers to be presented from the United States have already been arranged for from the recognised leading authorities on the various topics. Arrangements for the papers from foreign authors are being rapidly concluded, and the aggregation of papers which will be presented will constitute a broad review of the field and be of the highest value. Marked interest in the Congress from foreign countries continues, and there is every evidence that the attendance from abroad will be large. Full information concerning the Congress, the price of subscription, and the arrangement for purchase of volumes of the proceedings may be obtained by addressing the Committee of Management, International Engineering Congress, 1915, Foxcroft Building, San Francisco, California, U.S.A.

Conference of Mining Engineers.—At the sixtieth general meeting of the Institution of Mining Engineers, held last month, an interesting paper was read by Mr. J. J. Prest and Mr. J. Leggat, describing the sinking and equipment of Blackhall Colliery for the Horden Collieries, Limited, which, they said, is probably the last sinking of importance that will be made in the Durham coalfield. An interesting feature about the work was the use of liquid cement for stopping the flow of water in the limestone. The water in the north shaft was allowed to rise to its natural level, 186 ft. from the surface and 259 ft. from the bottom. From a temporary platform at water level eight columns of 3-in. pipes were run down to the bottom of the shaft, and a column of 15-in. air pipes was suspended in the centre of the shaft. Down the latter about 150 tons of 1½-in. broken slag were passed, which formed a conical mass at the bottom surrounding the 3-in. pipes. Down these 100 tons of liquid cement were then run through the slag, the result being to form a cement concrete plug about 15 ft. thick on the shaft bottom. A month later, the water having been pumped out to the level of the top of the plug, the cement was drilled out of the 3-in. pipes and the holes continued 30 ft. down into the strata below. Liquid cement was then forced down these holes by a cement pump at a maximum pressure of 700 lb. per sq. in., so as to fill the open fissures in the strata. In this way the feeders were reduced to quite a negligible quantity.

Quay Walls at Nantes, France.—Two types of quay walls of radically different design are now being constructed in the harbour of Nantes, France, on the Loire River, in connection with an enlargement of the port there. The first type is now under construction in an extensive new section of the harbour. The second type is a survival in reinforced concrete of a timber design which has been used for some years as an extension of existing walls of the old masonry retaining-wall type.

The first type is essentially a concrete retaining wall tied back by rods to deadmen in the earth fill and resting on a concrete slab, which in turn foots on reinforced concrete piles reaching down into the river bottom and side slope. In its final appearance this design is similar to many others common to European ports, but the peculiarity lies in the fact that the base concrete of the quay was placed in separately moulded reinforced concrete cribs. These cribs, which were 39·4 by 27 ft. in plan, were cast on the ground as hollow reinforced concrete boxes with fifteen circular openings symmetrically placed in the floor of the box, each opening 24 in. in diameter. The 20-in. reinforced concrete piles were driven in their proper position and the cribs swung into place and lowered over the piles, so that each pile fitted into the corresponding circular opening in the bottom of the crib and was stopped by the cross-bracing of the crib which passed directly over the opening. The whole crib was then filled up with concrete to make a solid box, the outside gravity wall tied in with rods to the deadmen, which were of concrete in 80-in. cubes, and the intervening space filled with earth to make the quay wall. This wall is to be some 5,600 ft. long.

The other structure, as stated above, is an evolution of old timber trestles which were built out beyond the masonry retaining walls to extend the width of the quay. Of late, however, these extensions have been built of reinforced concrete in the general type indicated. In building this extension reinforced concrete piles are first driven into the side slopes and on them reinforced concrete columns are cast, and are braced together in the truss section shown. A reinforced concrete floor with ordinary paving is also provided, and the whole structure is tied back to the deadmen at intervals.—*Engineering News.*

Reinforced Concrete in Greenhouse Construction.—It has been found in Germany that reinforced concrete can be used most economically and advantageously in the construction of greenhouses and hothouses. By courtesy of the *Tonindustrie Zeitung* we are able to reproduce here an interior and exterior view of a reinforced

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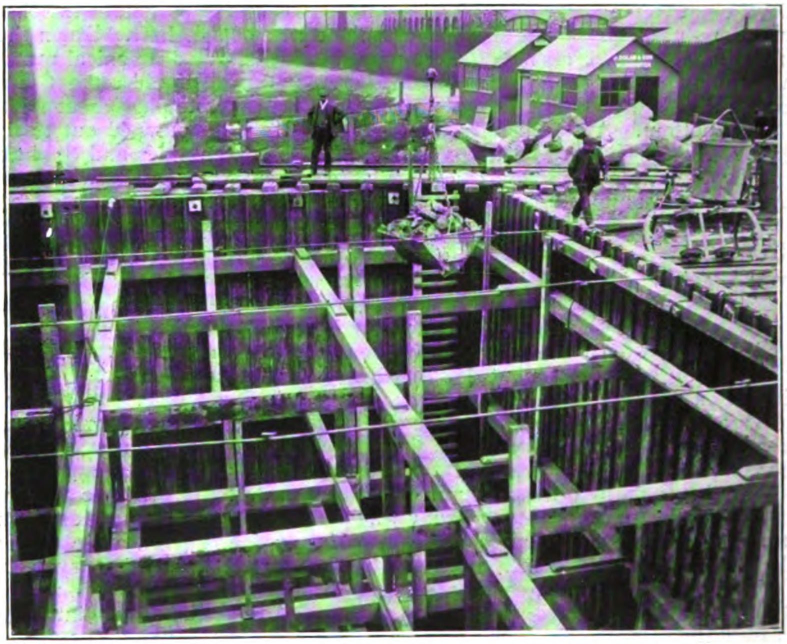

Illustration shows part of a four-sided Cofferdam 65 ft. × 35 ft. inside, constructed of Universal Joist Piling, 43 lbs. per super. foot in 42 ft. lengths for Transporter Bridge at Warrington.

THE WHOLE OF THE PILING (8,810 super feet) WAS DRIVEN IN TEN DAYS WITH ONE OF OUR No. 7 AUTOMATIC STEAM PILING HAMMERS

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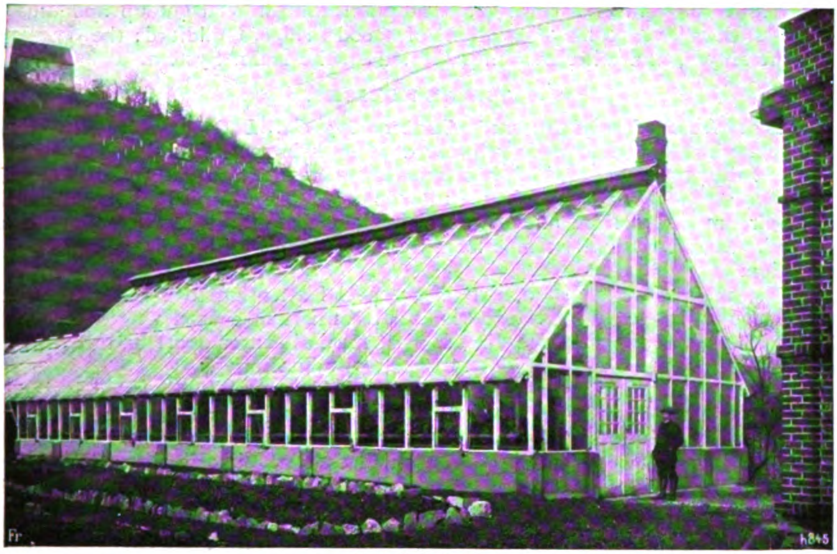
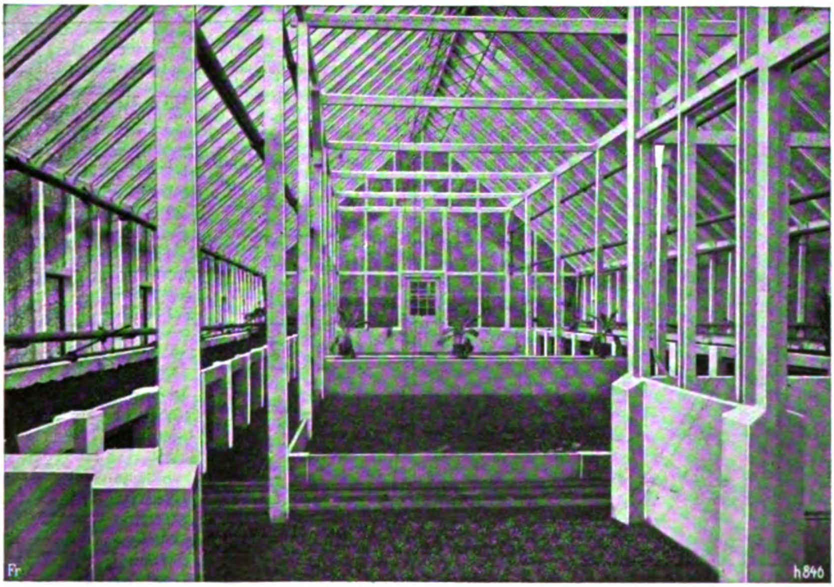
concrete greenhouse erected at Kirn a. Nahe. The framework of these greenhouses is built almost entirely of reinforced concrete, the doors only being of iron and timber. The maintenance costs are practically reduced to a minimum. The external walls



Exterior View.



Interior View.
Reinforced Concrete Greenhouse at Kirn a. Nahe, Germany.

consist of double or single reinforced concrete slabs. It is customary to deliver the different parts all ready for putting together, and the building up is thus accomplished quickly and easily. The heating, ventilation, etc., arrangements are simple.—Extracted from an article in the *Tonindustrie Zeitung*, of Berlin, No. 44, 1914.

PUBLICATIONS RECEIVED.

Kahncrete Engineering is the title of a new publication which has just been issued and is to be published bi-monthly. As indicated on its title-page and in the foreword, the journal is to be primarily a trade publication, and it will be the official organ of the Trussed Concrete Steel Co., Ltd. It is, however, intended also to publish general articles relative to reinforced concrete. The publication is well got up and illustrated, and the first number contains descriptions of Wood Bridge, Guildford; the Gramophone Factory at Hayes, and other buildings erected on the Kahn System.

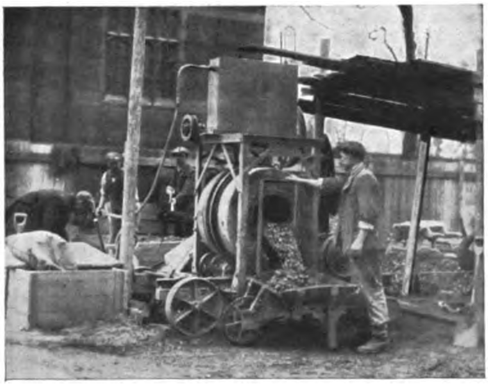
TRADE NOTICES.

The British Reinforced Concrete Engineering Co., Ltd., have recently published a small pamphlet on Road Beds reinforced with their special road bed mesh. It is pointed out that the change which has come about in the increased number of vehicles and the greater speed at which they are now driven have brought about quite different circumstances from any with which the road authorities have previously had to contend. The heavy motor traffic tears up the surface where the road bed is of weak construction.

The Company, in their pamphlet, draw special attention to a road-bed reinforcement which they have put on the market. It consists of a steel wire mesh made up of a series of parallel longitudinal wires held at fixed distances apart by means of transverse wires arranged at right angles to the longitudinal ones.

It is claimed that this mesh, acting as a reinforcement to the road bed, gives it the necessary strength and resiliency, and also that a big saving in maintenance is effected. Copies of this pamphlet, which, by the bye, contains a number of illustrations, can be obtained from the Company, at their address, 82, Victoria Street, Westminster, S.W.

"Auto" Oxy-Acetylene Welding.—We are informed that the War Office have accepted a tender for a large "Auto" stationary type acetylene generating plant, patent improved safety back pressure valve, and blowpipes with interchangeable nozzles for oxy-acetylene welding.



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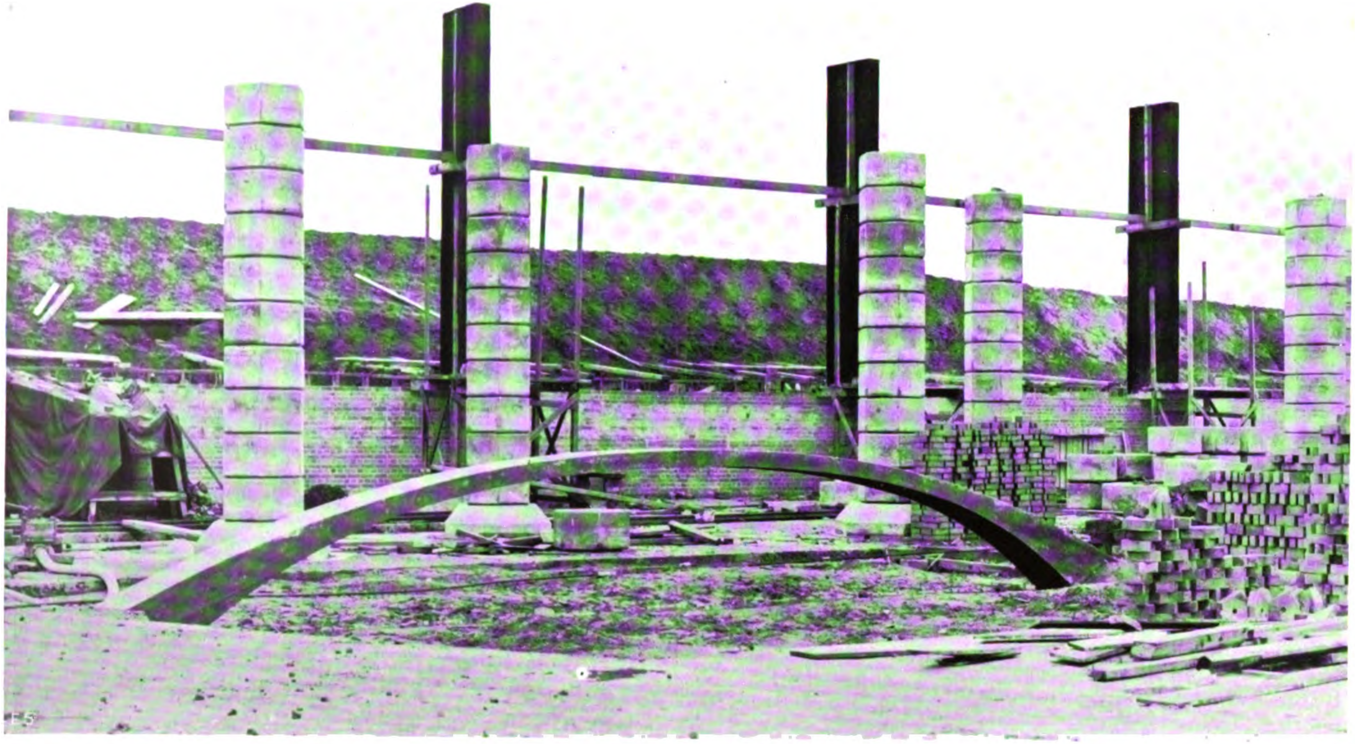


View showing full-size section of one of the Roof Domes to be tested to destruction.

Cross Hill Service Reservoir for Birkenhead Corporation.

(For description see p. 503.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume IX. No. 8. LONDON, AUGUST, 1914.

EDITORIAL NOTES.

OUR CONCRETE COTTAGE COMPETITION.

The Successful Exhibition of Designs.

It is with great pleasure that we are able to record that, apart from the excellent reception our competition has met with from all public authorities and other interests concerned, the Exhibition of the Competition Designs has been a remarkable success.

By the courtesy of the Council of the Surveyors' Institution, their splendid Lecture Hall was most kindly put at our disposal, and the 249 designs were arranged on special stands in bay fashion in such a manner that they were all easy to view.

Without any of those modern methods, such as formal opening speeches or the like, the exhibition—on its merits—attracted a most attentive audience during the week that it was open. Close upon a thousand visitors inspected the drawings, but it was not only the number of visitors that showed us the interest taken in the subject, but above all their standing in the official, technical and land-owning world. Headed by the Speaker, a number of members of Parliament visited the exhibition; distinguished landowners, headed by Lord Falmouth, devoted considerable time to examining the drawings. Representatives attended from H.M. Office of Works, the Local Government Board, the Board of Agriculture, the Admiralty, and other public departments; while from leading municipalities surveyors and architects attended from the departments primarily concerned, including the London County Council. Even the large railway companies showed their interest and sent several members of their staffs, and not least among our visitors were the directors of the great industrial concerns, such as Messrs. Rowntree, whose interest and enterprise in the subject matter is well known.

All this has gone to show us the wide interest that is being accorded to the subject and the absolute necessity of the problem of the cheap country cottage being solved.

If this journal has opened an entirely new aspect of the question by its competition and contributed something towards a successful elucidation thereof, our work will not have been in vain.

The Press on our Competition.

Our thanks are due to the technical Press for the courteous manner in which they have received our enterprise. Notable among our commentaries were the following:—

The Builder:

> The Competition inaugurated by CONCRETE AND CONSTRUCTIONAL ENGINEERING has met with an excellent response. . . . The Assessors of the Competition, Messrs. Max Clarke, Beresford Pite, and Edwin O. Sachs, have, we consider, made an excellent choice, and we entirely endorse their findings. We do not wholly agree with the suggestion that a height of 8 ft. is sufficient for rooms in a country cottage on the ground that doors can be left open and that the occupants of such cottages spend much time out of doors. We are inclined to think that 9 ft., or, at the very least, 8 ft. 6 in., should be made an irreducible minimum, but that is a point of detail. . . .

The British Architect:

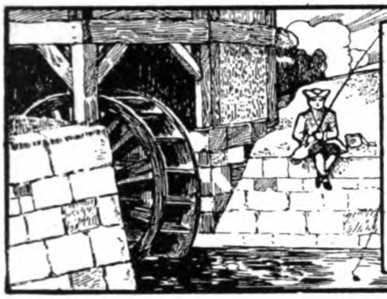
> We need not measure or estimate the results before we appraise the enterprise which made the Concrete Cottage Competition possible. It was a timely and valuable project, and perhaps even the fact that it has brought into prominence the difficulties of the subject is one of the best justifications for the effort to elicit some attempts to solve this everlasting problem of the cheap cottage. Of course, no building is really cheap which is not durable; nor is it satisfactory for its inhabitants unless it is warm, sanitary, and weatherproof. In these aspects—economy, comfort, and healthiness—one can hardly doubt the concrete cottage ought to take a prominent place. Probably we may take it that the competition which our contemporary has instituted has helped still further to emphasise these facts.

The Surveyor and County Engineer:

> HOUSING THE LABOURING CLASSES.—It was an excellent idea of the proprietors of CONCRETE AND CONSTRUCTIONAL ENGINEERING to offer a number of prizes, varying in value from 100 to 10 guineas, for designs of small cottages suitable for rural districts, the cost of which was not to exceed £125 each, exclusive of builder's profits. . . . The first prize of £105 has, as stated elsewhere in this issue, been awarded to Mr. Ernest S. Thompson, a Westminster architect, who has strictly adhered to concrete throughout. His design has many novelties, and is of a bungalow type with a flat projecting roof of reinforced concrete. The interior arrangements have been well designed to prevent any waste of domestic labour, and seem to meet all the requirements of a cheap, substantial, attractive cottage. It would be a worthy enterprise if someone would erect a few cottages of this type, and possibly others from the chosen designs, in order to see if they could be erected at the price, and also to ascertain, if possible, the class of cottage which would be most popular among the labouring classes. The proprietors of CONCRETE AND CONSTRUCTIONAL ENGINEERING are to be warmly congratulated on their enterprise in having initiated this Competition on lines which are so thoroughly practical and so devoid of the usual sentimental theorising which is too often adopted when dealing with this difficult and complicated problem.

Licences for the Premiated Competition Designs.

Licences can be obtained in respect of the premiated designs on application to the Secretary, Concrete Publications, Ltd., the North British and Mercantile Building, Waterloo Place, London, S.W.



CROSS HILL SERVICE RESERVOIR.

By ALBERT LAKEMAN, M.S.A.

Some very interesting reinforced concrete work is being carried out for the Birkenhead Corporation in connection with the water supply, and we give below a short article on this work.—ED.

THIS large service reservoir is being constructed in connection with the water supply for the Birkenhead Corporation from the Alwen in North Wales, and it contains some very interesting features in its design and construction. The water is conveyed a distance of 42 miles, and the scheme has been prepared by Sir Alexander Binnie, Son and Deacon, Civil Engineers, St. Stephen's House, Westminster, who have been successful in evolving an exceptionally cheap and efficient method of construction in the reservoir, which should commend itself to all those engaged in this class of work.

The reservoir has an area of water of about 4 acres, and it will act as an emergency supply in the event of any accident occurring in the supply pipes, which extend over such a great distance, and for this reason it required to be a covered reservoir, as the water will pass on the outside by means of a by-pass in the ordinary way, and will not enter the reservoir after this has become full. The reservoir is also covered, because it is required to store filtered water. The plan is that of an hexagon with a width between two opposite parallel faces of about 460 ft., and it is 29 ft. deep, thus having a capacity of 30,000,000 gallons of water. The length of one side of the hexagon is about 245 ft., and the outer walls are constructed with brindled brickwork and concrete designed to resist the thrust of the earth, which is banked up against the walls on the outside, when the tank is empty, and they are not designed to resist the water pressure by their own weight, but merely transmit the thrust to the earth, which is thrown up to form an embankment having a slope of 2 in 1. The brickwork is built in the form of horizontal arches, having the concave side to the water, each having a span of 28 ft., and the abutments for these are formed by large steel girders, as shown in the illustrations in *Figs.* 2 and 3. These are plate girders 4 ft. deep and about 30 ft. 6 in. long, extending about 2 ft. below the floor level, and the thrust from the arched walls is transmitted to these plate girders, which in turn transmit the thrust to the floor and roof of the reservoir. The brickwork is carried around the girders on the inside to form an effective covering, specially made bricks being employed as required, and a filling of cement concrete is provided at the back of the brickwork, as shown in the illustrations, making the total thickness of the wall at the crown of the arch 2 ft., this increasing to 5 ft. 4 in. at the abutment owing to the outside face of the concrete not being concentric with the line of the brickwork. A layer of Seyssel asphalt, $\frac{3}{4}$ in. thick, is placed between the brickwork and the concrete, and this is carried through the thick-

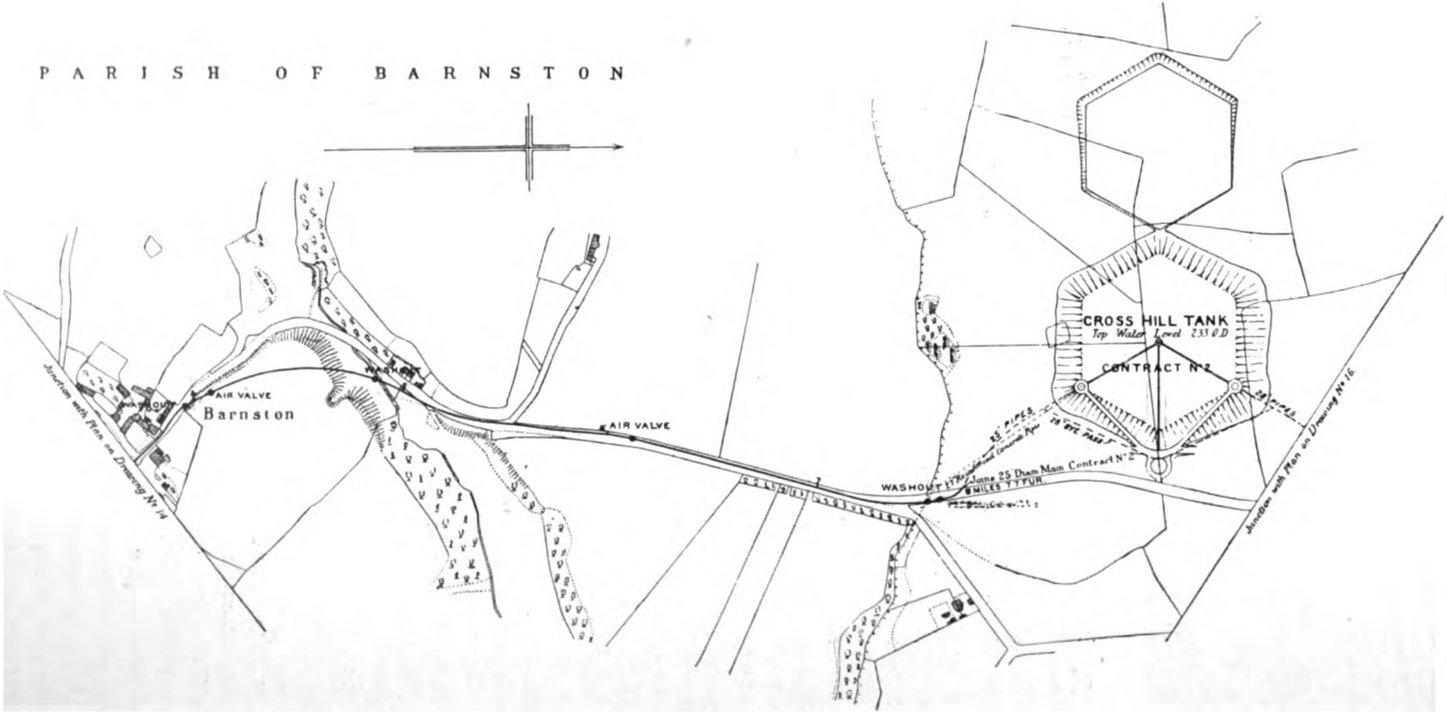


Fig. 1. Plan.

Cross Hill Service Reservoir for the Birkenhead Corporation.

ness of the floor to form a continuous watertight lining for the whole tank. The brickwork is built in mortar composed of 2 parts good clean sand and 1 part Portland cement, and the concrete is mixed with 5 parts coarse and fine aggregate and 1 part Portland cement. The covering to the reservoir is designed in the form of 216 hexagonal concrete domes, each of which is supported by six hexagonal pillars constructed with moulded concrete blocks. Each pillar has a sectional area of 6 sq. ft., and the blocks are moulded with a chamfered edge, as shown in *Fig.* 4, to avoid the chipping that is liable to occur with ordinary square edges. The photograph referred to in *Fig.* 4 is a view of the block-making yard, and it will be noticed that each block has a hole in the centre. These holes extended for the full height of the pillars, and when the blocks were set in position liquid Portland cement mortar was poured in to form a continuous mortar dowel passing through the whole of the courses. The concrete for these blocks is composed of crushed limestone broken to pass ½-in. mesh and Portland cement in the proportions of 5 and 1, and particular care was exercised in the casting.

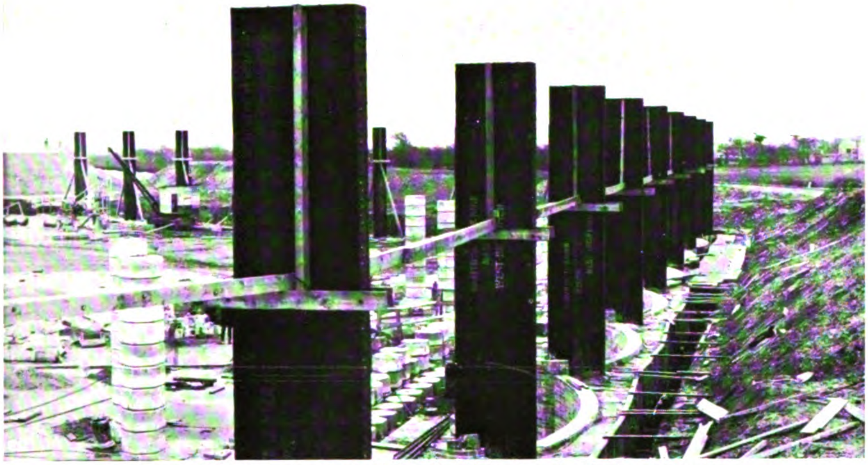


Fig. 2. View Showing Steel Girders for Abutments for Horizontal Arches.
Cross Hill Service Reservoir for the Birkenhead Corporation.

It is a well-known fact that concrete moulded by the vibratory method is much stronger than that cast in the ordinary way, owing to its greater density, and this fact was taken advantage of by the engineers, who devised a simple method of agitating the moulds while the concrete was being placed, it being found less expensive than to cast each one separately on a vibratory table. The moulds were struck one week after the concrete was placed, and the blocks were then exposed for three months before being used. The domes are so arranged that there is no oblique thrust on these pillars and the load is a vertical one only, and the cap to the pier consists of a specially shaped block, having a hole in the centre similar to the other blocks, but in lieu of the cement dowel mentioned above a steel rod passes right through the cap and enters the upper part of the pier. A shaped steel plate covers the top of the cap, and to this the joists which support the groins of the domes are riveted. The base of the piers is also formed with a special block and this rests on a foundation of cement concrete 2 ft. thick. The domes are constructed of plain concrete, with one rolled steel joist on the line of each groin, these groins being 16 ft. long and having a rise of 1 ft. 4 in. from the springing to the height point at the centre. Each groin has a sectional area of 1·3 sq. ft., and the shape is such that the thrust from the plain concrete on either side is met by a surface at right angles to it. The span of each dome is 30 ft. in the clear, and no reinforcement is provided apart from the steel in the groins mentioned above. The concrete has a minimum thickness of 6 in., and it increases towards the groins, as shown in our frontispiece,

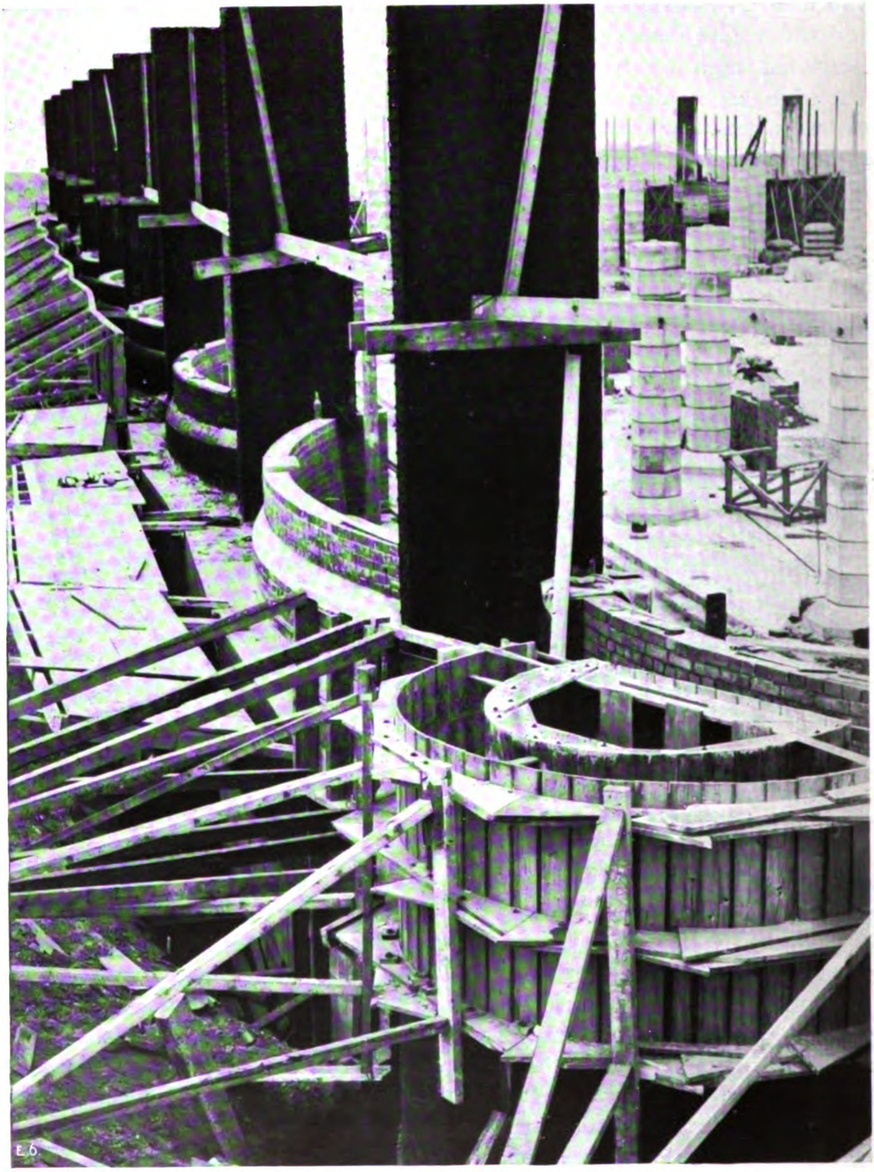


Fig. 3. **Further View of Steel Girders for Abutments.**
Cross Hill Service Reservoir for the Birkenhead Corporation.

illustrating a test piece, which has been made and will be tested to destruction at a later date. It will be seen that the line is a particularly graceful one, and it is believed that the test will prove the strength to be far in excess of that actually required in the work itself. The centering to the dome is not to be struck under a period of three weeks from the time the concrete is deposited. The concrete domes are to be covered with a layer of dry filling, which will be placed to give perfectly symmetrical loading, and

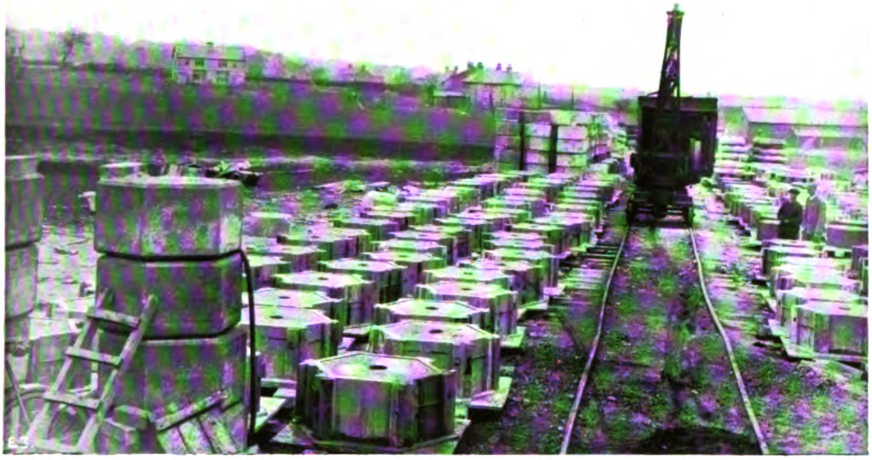


Fig. 4. View of Block Yard, Showing Concrete Blocks.
Cross Hill Service Reservoir for the Birkenhead Corporation.

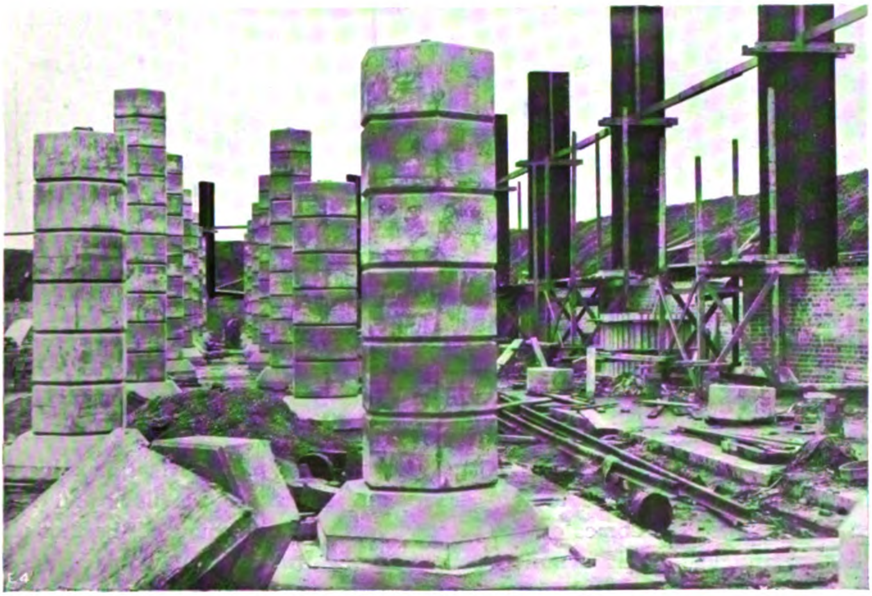


Fig. 5. View Showing Reinforced Concrete Columns.
Cross Hill Service Reservoir for the Birkenhead Corporation.

concrete drains with open joints will be laid over the concrete to collect any water at the lowest points, and this will be conducted to a low-level drain, 2 ft. 6 in. diameter, also of concrete and with open joints, which is laid around the walls on the outside. The dry filling will be covered with earth, and grass seed will then be sown over the whole surface.

The floor of the reservoir is composed of concrete, 12 in. thick, with an increase to 2 ft. under the piers and 3 ft. under the walls, with the continuous asphalt layer in the thickness as previously mentioned.

The nature of the construction is very economical, as will readily be understood when it is stated that the cost of the reservoir only works out at £2,600 per million gallons, which is much below the average cost of covered reservoir work. The whole of the constructional features have been very carefully calculated, and the design is such that the component parts of the structure are dependent on one another in a manner very different to the general rule. This is so much the case, that the engineers carefully considered the order in which the work should be executed and drew up a specification for the order which the contractor has to adhere to rigidly.

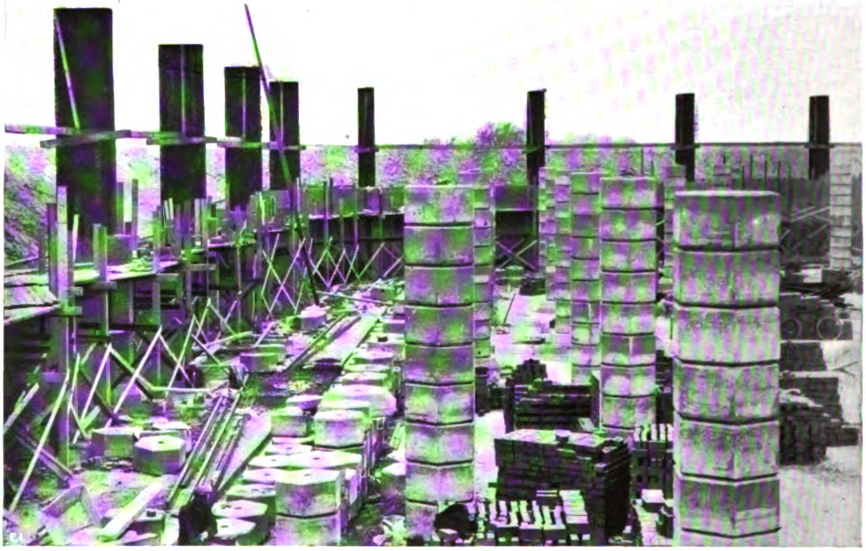


Fig. 6. View Showing Column Work.
Cross Hill Service Reservoir for the Birkenhead Corporation.

It will be seen that the thrust of the earth embankment is taken by the walls, which transmit same to the girders and thence to the floor and roof, while the thrust of the domes on the piers is vertical on account of the fact that the design and loading is symmetrical, and the thrust of the water is transmitted through the walls to the earth, and therefore if a portion of the reservoir were completed before the remainder there would be a possibility of failure, or at least cracks appearing, which would be fatal to efficient construction. The scheme has been well considered and the result justifies the great care bestowed upon it, and reflects great credit on the engineers responsible for its conception and supervision.

The contractors for the work are Messrs. McAlpine and Sons of Glasgow.

SHEAR IN REINFORCED CONCRETE BEAMS

(NOTES ON DESIGN).

By ROHINTAN N. FRAM MIRZA, B.Eng. (Livpl.), A.M.I.C.E., etc.

The following Notes on design regarding Shear in Reinforced Concrete Beams, should be of interest to engineers and others who have to deal with this question.—ED.

In the present article, equations, deductions and suggestions are given in the hope that they may be of use in rapidly designing details with regard to shear.

The calculations are based on the following fundamental theorems (the proofs of which are not discussed here).

(1). A simple shear can be always analysed into two equal and opposite principa stresses, one compressive and the other tensile, acting at right angles to each other, and inclined at 45° to the direction of the shearing stress.

(2). A tangential stress cannot exist in one direction unless it is accompanied by a tangential stress of equal intensity acting in a direction at right angles to the first direction. (*Rankine's Theory of Internal Stress*).

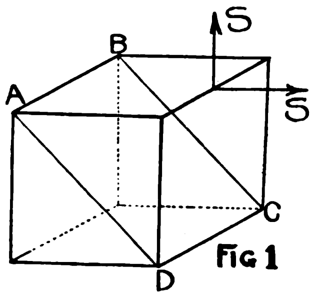


FIG 1

Consider the simple case of a cube (*Fig.* 1), the area of one face being, say, β square units. Let S represent the total shearing force and the intensity of shearing stress is $q=\frac{S}{\beta}$. Then a tensile stress will act over the whole of the diagonal plane $ABCD$, of intensity exactly the same as that of the horizontal or vertical shearing stress q, and a compressive stress will act over the whole of the other diagonal plane at right angles to the plane $ABCD$ of intensity equal to that of the vertical or horizontal shearing stress q. (For proof, *Goodman's Mechanics*, p. 314; *Wood's Strength and Elasticity of Structural Members*, p. 40, etc.)

Nomenclature (*R.I.B.A. Report* No. 2, 1911).

b and d = Effective breadth and depth of beam in inches.

b_r and d_s = Width of stem or rib and depth of slab in inches for **T**-beams.

n = Neutral axis depth and $n'=n/d$ and $j=(1-\frac{n'}{3})$.

l = Effective length of a beam in inches.

$r=At/bd$, *i.e.*, ratio of *tensile* reinforcement to the area bd.

W = Total load in lbs. W_c = Total weight of concrete beam.

w = Load per inch run. w_c = weight of concrete in beam per in. run.

$B.M.$ = Bending moment at a section in inch-lb. units.

a = Lever arm $=d(1-n'/3)=jd$.

q_{av} = average intensity of shearing stress on a section $= \frac{S}{bd}$.

S = Total shear in lbs. on a vertical section.

S_e = Total shear in lbs. at points of support.

A_s = Cross sectional area of a vertical or diagonal shear member or a group of members in space p or dx (term dx is more convenient when using differential calculus) where p or dx equal to pitch of stirrups or shear members.

c = working compressive stress in concrete in lbs./sq. in.

C = Total compression in concrete in lbs.

t = working tensile stress in steel in lbs./sq. in.

T = Total tension in steel in lbs.

s = Intensity of shearing stress on concrete in lbs./sq. in.

s_s = Intensity of shearing stress on steel in lbs./sq. in.

u = variable distance away from and perpendicular to neutral plane.

dM = difference between the values of Bending Moments on two sections close to each other.

Abbreviations used.

N.A. = Neutral axis.
R.C. = Reinforced concrete.
Max. = Maximum.
Min. = Minimum.
Vert. = Vertical.
Hrztl. = Horizontal.
C.L. = Centre line.

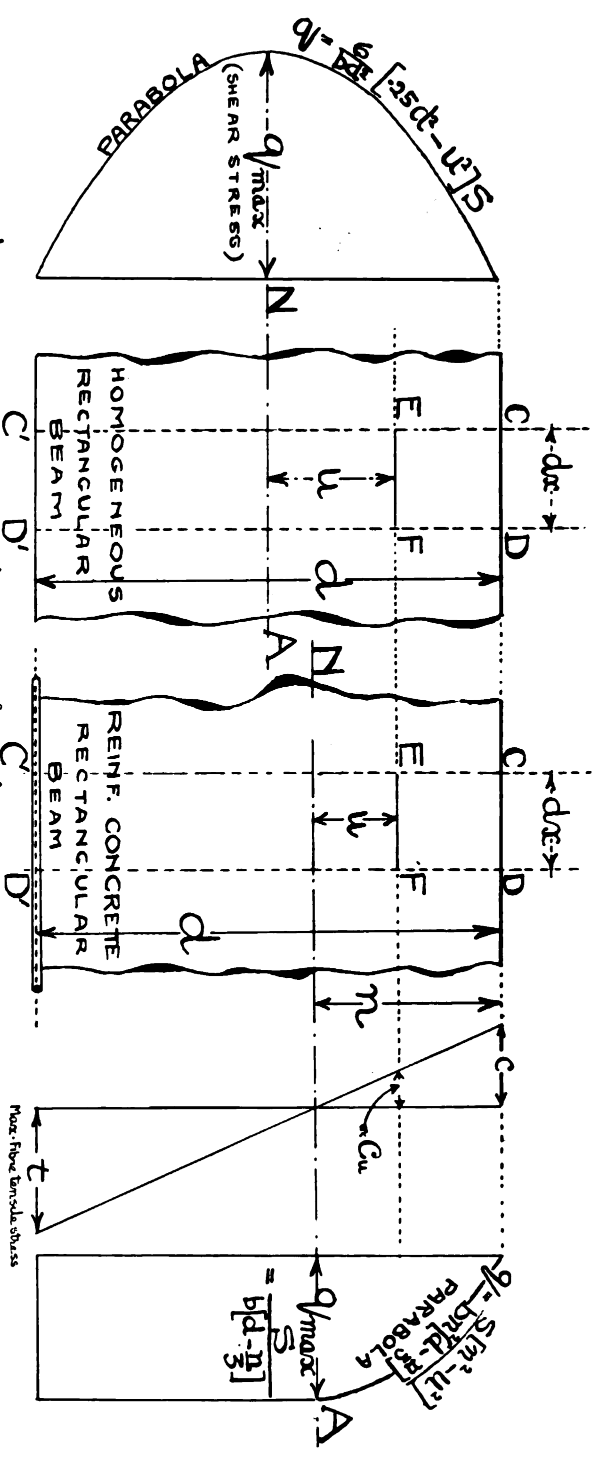

PARABOLA
$q = \frac{6}{bd^3}[.25d^2 - u^2]S$
q_{max}
(SHEAR STRESS)
N
HOMOGENEOUS RECTANGULAR BEAM
C
D
C'
D'
E
F
u
dx
d
A
N
REINF. CONCRETE RECTANGULAR BEAM
C
D
C'
D'
E
F
u
dx
d
n
c
C_u
t
Max. Fibre tensile stress
$q_{max} = \frac{S}{b[d - \frac{n}{3}]}$
$q = \frac{S[n^2 - u^2]}{bn^2[d - \frac{n}{3}]}$
PARABOLA
A

FIG 2

dx = an elemental of beam length

q = Intensity of Shear Stress i.e. Total Shear in lbs at a section ÷ area of section

DISTRIBUTION OF SHEAR STRESS.

(1) In Homogeneous Beams.

Let CC' and DD' in *Fig.* 2 be two vert. sections of a beam separated by a very small distance, dx. Remembering that the shear stress at any point in a vert. section of a beam is accompanied by a shearing stress of equal intensity on a hrztl. plane through the point (Theorem 2), the intensity of shear stress in section CC' at, say, E (any distance u away from N.A.) must equal the intensity of shearing stress in plane EF.

This is the condition existing at any portion of the beam, and naturally the problem arises as to what is the sum total effect of this for the whole beam, or in other words, how does the intensity of shear stress vary from the uppermost surface to bottom surface of the beam ?

For any rectangular homogeneous beam of constant breadth, b, and constant depth, d, the solution of the problem (for full information *vide Goodman's Mechanics*, p. 381 ; *Perry's Calculus for Engineers*, p. 117 ; *Wood's Strength and Elasticity of Structural Members*, p. 131, etc.) is as follows:—q, *i.e.*, the intensity of shearing stress $=\frac{S}{2I}[\cdot 25d^2-u^2]$ where I equals the moment of inertia of the section about N.A.

$$\therefore\ q=\frac{6}{bd^3}[\cdot 25d^2-u^2]S \tag{1}$$

This will be at once recognised as the equation for a parabola, and further shows that q is max. at N.A. (*i.e.*, when $u=0$) and vanishes at the top and bottom of section, *Fig.* 2.

Hence for a rectangular section the max. q will be $\frac{3}{2}$ (by the property of a parabola) times the mean intensity which will be obviously $\frac{S}{\text{area of section}}$.

As a further example :

For a circular section, max. intensity is $\frac{4}{3}$ of the mean intensity, *i.e.*, $\frac{4}{3}\,\frac{S}{\pi R^2}$, the value S depending on the position of section along the beam and the manner of loading.

From what has been stated it is evident that the max. intensity of tensile and compressive stresses on planes inclined at 45° to hrztl. will occur at points on the plane of max. shear (*i.e.*, also on the neutral plane) and these stresses are equal to the vert. and hrztl. shear at those points. (Theorem 1.)

(2) In Reinforced Concrete Beams.

In a R.C. beam the variation in shear intensity differs from that in a homogeneous beam only below the N.A. owing to the concentration of tensile stress into the steel. The distribution of shearing stress on vert. section of a R.C. beam is shown by *Fig.* 2.

From the top surface (rectangular beam, constant b and d) up to the neutral axis. it follows the law

$$q=\frac{S(n^2-u^2)}{bn^2\left(d-\frac{n}{3}\right)} \tag{2}$$

consequently on the topmost layer where $u=n$, q is nil and increases at N.A. to the max. value

$$\frac{S}{b\left(d-\frac{n}{3}\right)}=\frac{S}{bdj}=\frac{S}{ba} \tag{3}$$

From N.A. to the bottom layer q remains constant and works out equal to $\frac{S}{b\left(d-\frac{n}{3}\right)}$, for no tension is considered as acting in the concrete, and hence no change in the intensity of vertical and horizontal shearing stresses.

$\left\{ \right.$ Proof of equation $q = \dfrac{S\,(n^2 - u^2)}{bn^2\left(d - \frac{n}{3}\right)}$ see Fig. 2.

Consider two adjacent sections CC' and DD', between which on the plane EF are applied shearing stresses. Equating the forces for equilibrium $qb \times dy$ must equal $\int_u^n b \cdot du \cdot dc_u$ (3a)

c_u being the stress at point under consideration (*vide Fig.* 2).

Again c the compressive stress on concrete $= \dfrac{2M}{bn\left(d - \frac{n}{3}\right)}$ $\therefore$ differentiating $\dfrac{dc}{dy} = \dfrac{2\,\frac{dM}{dY}}{bn\left(d - \frac{n}{3}\right)}$.

but $\dfrac{dM}{dY} = S$ (see *Perry's Calculus*, p. 109; *Goodman's Mechanics*, p. 400) $\therefore \dfrac{dc}{dy} = \dfrac{2\,S}{bn\left(d - \frac{n}{3}\right)}$ (3b)

From Fig. 2. it is evident that $dc_u = \dfrac{u}{x}\,dc$

Therefore $qb \cdot dy = \int_u^n b\,.\,du\,.\,\dfrac{2uS\,.\,dy}{bn^2\left(d - \frac{n}{3}\right)}$ $\therefore$ $qb = \dfrac{2S}{n^2\left(d - \frac{n}{3}\right)} \int_u^n u.du$ (3c)

$$\therefore \quad q = \frac{S(n^2 - u^2)}{bn^2\left(d - \frac{n}{3}\right)} \tag{3d}$$

Below neutral axis.

$$q \cdot b \cdot dy = d\,(T)$$

$$\left.\text{but } T = \frac{M}{d - \frac{n}{3}} \therefore \frac{d\,(T)}{d\,(y)} = \frac{\frac{dM}{dY}}{d - \frac{n}{3}} \text{ hence } q_{\text{max.}} = \frac{S}{b\left(d - \frac{n}{3}\right)}\right\} \tag{3e}$$

$$\text{For T Beams } Max.\ q = \frac{S}{b_r\left(d - \frac{n}{3}\right)} \text{ or very nearly} = \frac{S}{b_r(d - \cdot 5d_s)} \tag{4}$$

The above equations give the maximum shear intensity to be dealt with while designing. It may be of interest to note that generally the value $\left(1 - \frac{n'}{3}\right)$ ranges very close to 7/8; hence $Max.\ q' = .\dfrac{8}{7}\dfrac{S}{bd}$ that is the shearing stress at $N{\cdot}A{\cdot}$ (where it is a maximum) is 14% more than the average value $\dfrac{S}{bd.}$

WEB REINFORCEMENT.—FUNDAMENTAL EQUATIONS.

In a R.C. beam the steel reinforcement is assumed to resist all the tension. Consider CC' and DD' in *Fig.* 3 as two vert. sections in a beam separated by a distance p or dx. Then the B. Moment at CC' will not be same as at DD'; hence there will be a difference in the tensile stress at the two sections. Again, Tension × Lever Arm = B.M.; there the difference in tensions $T_1 - T_2 = \dfrac{BM_1 - BM_2}{Lever\ Arm}$. It is this difference which is communicated from steel to concrete by adhesion and produces a shearing stress in the concrete above the steel, and is distributed over an area $b \times dx$ or $b \times p$.

Further, the difference between the Bending Moments in a length p or dx is equal to the average shearing force on the space p or dx, multiplied by this length; in other words, $\dfrac{dM}{dx} = S$ [see *Perry's Calculus for Engineers*, p. 109; *Goodman's Mechanics*, page 400; *Lincham's Mechanical Engineering*, page 437, etc.], dM standing for $BM_1 - BM_2$.

Equating the forces acting in space p or dx for equilibrium, it follows that

Resistance offered by concrete + Resistance offered by stirrups must equal the difference in tension ; hence

$$s\cdot b\cdot p + A_sS_s = T_1 - T_2 = (BM_1 - BM_2)\big/\text{Lever Arm} = \frac{Sp}{a} \qquad (5)$$

When stirrups are inclined at θ° to the horizontal [for good practice θ ranges from 90° (*i.e.* vertical stirrups) to 45°].

$$s\cdot b\cdot p + A_sS_s = \frac{Sp}{a}\sin\theta \qquad (6)$$

Taking the safe value of s (*i.e.* shear stress on concrete) as 60 lbs/sq. in.

$$A_s = p\frac{(S-60ba)}{aS_s}\sin\theta = p\frac{b(q-60)}{S_s}\sin\theta \qquad (7)$$

In the case of T beams b_r should be substituted for b.

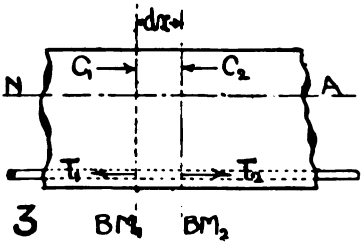
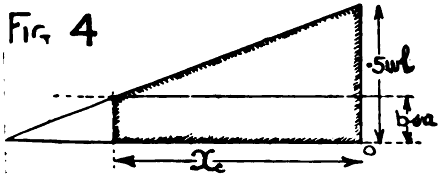


FIG 3

Fig 4



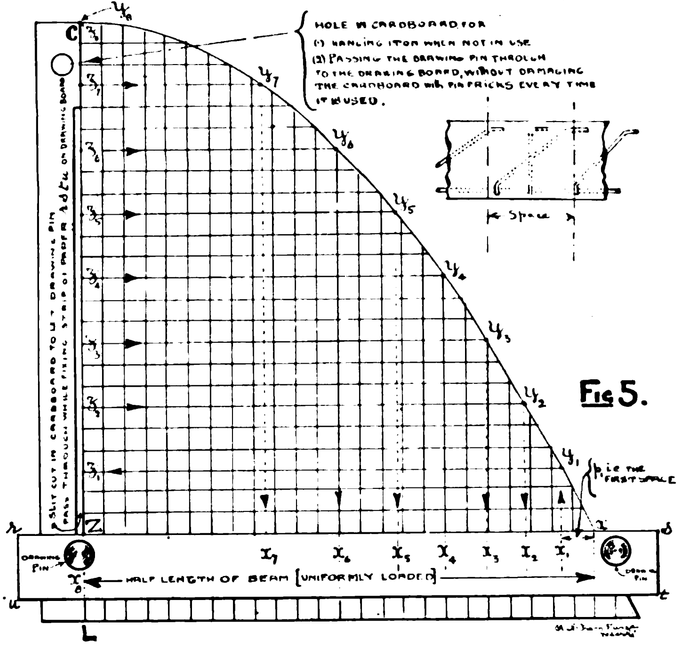

y8
C
z8
z7
z6
z5
z4
z3
z2
z1
Z
y7
y6
y5
y4
y3
y2
y1
HOLE IN CARDBOARD FOR
(1) HANGING IT ON WHEN NOT IN USE
(2) PASSING THE DRAWING PIN THROUGH TO THE DRAWING BOARD, WITHOUT DAMAGING THE CARDBOARD WITH PIN PRICKS EVERY TIME IT IS USED.
SPACE
SLIT CUT IN CARDBOARD TO LET DRAWING PIN PASS THROUGH WHILE FIXING STRIP OF PAPER Adhere ON DRAWING BOARD
p1 I.E THE FIRST SPACE
r
s
t
u
DRAWING PIN
X7
X6
X5
X4
X3
X2
X1
X
X0
HALF LENGTH OF BEAM [UNIFORMLY LOADED]
DRAWING PIN
L

Fig 5.

The following table gives the value of S for four types of girders, at the support and at any point x units away from the same. For continuous girders the latter half of the table only applies to the portion of beam lying between points of contraflexure. (*Vide* the excellent illustrations given in *Goodman's Mechanics*, pp. 402-421.)

Type of Cantilever or Beam.	S_x at any distance x from abutment.	S_e at abutment.
Cantilever—Concentrated load at end	W	W
Cantilever—Uniformly distributed load w over length L	wx	wL
Beam—Supported at two ends, Concent. load W in middle	$\cdot 5W$	$\cdot 5W$
Beam—Length L, supported at two ends Uniformly distributed load w	$\left[\cdot 5L - x\right]w$	$\cdot 5wL$

FORMULÆ

for calculating rapidly when estimating the total area of steel to resist the shear in a beam, and hence also the number of stirrups. These formulæ do not take into account any reduction in the number of stirrups, by cranking up some of the main reinforcing rods. Each formula as deduced is multiplied by 1·25, *i.e.* increased by 25 per cent. (this may also be left to the discretion of the designer) to meet contingencies when the beam has actually to be designed, for more often than not the commercial section will be used even if the theoretically deduced area of a bar or stirrup is a little smaller.

(1) Uniformly loaded beam supported at ends. For a continuous beam the portion between points of contraflexure to be considered. Symbol w may also be made to include weight of concrete in beam per inch run, then

Total area of metal (for whole beam length) to resist shear

$$= \frac{(\cdot 5wl)^2 - (b.s.a)^2}{w.S_s.a} \times 1\cdot 25 \times \sin\theta \qquad (8)$$

It is better to leave $\sin\theta$ out, as one can never tell beforehand exactly how many bars will be bent up.

{Proof for Equation 9. Consider a small elemental length of beam dx, then, according to Equation (8), $d(A_s) = \frac{S}{aS_s}.dx$, but $S = \cdot 5lw - xw$, *i.e.* the shear at any section in lbs.

$\therefore$ Total area of metal in shear for ½ length of beam $= A_s$

$$= \int_0^{x_c} \left(\frac{\cdot 5lw - xw}{aS_s}\right).dx \qquad (9)$$

where x_c is evidently $= \frac{\cdot 5lw - bsa}{w}$, see *Fig.* 4.

$\therefore A_s$ for ½ beam $= \left[\frac{\cdot 5lwx - \cdot 5x^2w}{aS_s}\right]_0^{x_c}$

$\therefore A_s$ for whole beam $= \frac{(\cdot 5wl)^2 - (bs.a)^2}{w.S_s.a}$ assuming $\theta = 90°$}

(2) Beam supported at ends. Concentrated load W.

Weight of beam in concrete per inch run w_c. Total beam weight W_c.

$$A_s \text{ for whole beam } = \frac{\cdot 25[W + W_c]^2 - (b.s.a)^2}{w_c.S_s.a} \sin\theta \times 1\cdot 25 \qquad (10)$$

Leaving the factor 1·25, even out, the above formulæ are mathematically deduce to give A_s a little greater (so as to err on safety side) by neglecting s in length x_c.

RATIO OF LENGTH TO DEPTH FOR EQUAL STRENGTH IN MOMENT AND SHEAR.

Single concentrated load (beam supported on ends), constant b and d

$$l/d = 2tjr/q_{av} \qquad (11)$$

Example : $r = \cdot 01$, $t = 16000$, $q_{av} = 50$ lbs./sq. in., $j =$ say 7/8 $\therefore l/d = 5\cdot 6$.

Uniformly distributed load (beam supported on ends), constant b and d

$$l/d = 4tjr/q_{av} \qquad (12)$$

Example as above : $l/d = 11\cdot 2$.

For any beam. W can always be expressed in terms of S, and also separately in terms of $B.M.$ Equate the two and obtain expression for l/d.

RAPID GRAPHIC METHOD

for determining the spacing of stirrups in uniformly loaded beams only. Special requirement—One squared paper sheet cut out in the shape of a parabola and gummed on stout cardboard. (See *Fig.* 5).

Consider beam as having been already designed for tension members. As an example (rectangular beam, freely supported), $l = 144$ in., $w = 694\cdot 45$ lbs./in. run. $W = 100{,}000$ lbs., $b = 16$ in., $r = 1\cdot 5\%$ top and bottom, $n' = \cdot 396$; hence $j = \cdot 868$, $d = 25$ in. and $a = jd' = .22$ in.

Decide on values of s, S_s and θ, which here assume as 30, 12,000 and 90°. Consider only one-half of beam. Concrete helps to resist shear at 30 lbs./sq. in., to determine after what length of beam, say x_c from support, stirrups will be unnecessary. Obviously this occurs where $(\cdot 5l - x_c)w = bsa$.

$$\therefore \; x_c = (\cdot 5lw - bsa) \div w \qquad (13)$$

hence $x_c = (50000 - 10560) \div 694\cdot 45 = 57$ in. $= 4$ ft. $- 9$ in. Again, if $\cdot 5lw$ is $\leqq bsa$, no stirrups will be required.

To be effective in design, following should be observed :—

(1) Up to ¼ length of beam from support the spacing should not be > than $\cdot 5\underline{a}$ for vert. stirrups and $\underline{a}$ for 45° inclined stirrups.

(2) One of the two side-by-side stirrups should be vert. and the other inclined, for inclined ones resist initial failure under low loads, while verticals appear to resist greater distortions under big loads.

For ***estimate purposes*** total area of steel for shear in whole beam =

$$\frac{(\cdot 5wl)^2 - (bsa)^2}{wS_s a} \times 1\cdot 25 = 13 \times 1\cdot 25 \text{ sq. in. } \therefore \text{ for half beam } 6\cdot 5 \times 1\cdot 25 \text{ sq. in.} \qquad (14)$$

Method of Design.—To start with, make the first space one-fourth of the lever arm, *i.e.*, $(a \div 4) = 22/4 = 5\cdot 5$ in.

Take a strip of paper *rstu* (see *Fig.* 5) and mark off xZ (half length of the uniformly loaded beam) to some convenient scale, and place it horizontally on the squared paper cut out in the shape of a parabola, so that point x may lie on the curve and Z on the centre line CL (*Fig.* 5 is self explanatory).

[Preferably the sectional paper should be first gummed on a stout piece of cardboard, then cut out in the parabola form and afterwards varnished over, so that it may stand the usage in the drawing office.]

Mark off the first space p_1 as xx_1 on the paper strip from the support side of the beam, and project x_1 on the parabolic curve as y_1 and then reproject y_1 on centre line CL as z_1 (to do this operation use very faint pencil only, if necessary).

From z_1 lay off divisions z_1z_2, z_2z_3, z_3z_4, etc., all equal to Zz_1 with a pair of dividers (the points of the divider may be kept in the slit specially made in the cardboard, see *Fig.* 5). Chances are that it will be found that the divisions thus adopted will not divide the maximum ordinate ZC into equal parts, and to obtain good results it is necessary that ZC should be divided into equal parts. In the present example if p_1 were taken equal to 5·5 in., the max. ordinate ZC is divided into six equal parts and a little remainder, hence at this stage a little simple manipulation is required. After making one or two trials it will be found that by making the first space 5 in. instead of 5·5 in., the ordinate ZC is divided into eight equal parts (see *Fig.* 5) Zz_1, z_1z_2, etc.

It should be observed that the maximum ordinate should be always divided into so many equal parts as the case may be, in such a way that z_1 projected on x_1Z as x_1 through y_1 does not give the first space from the support > the amount $\cdot 5a$ or $\cdot 25a$, as decided upon.

Again project horizontally points z_2, z_3, z_4, etc., on to the curved side as y_2, y_3, y_4, etc., and reproject these vertically downwards as x_2, x_3, x_4, etc., on the horizontal line xZ, then xx_1, x_1x_2, x_2x_3, etc., each represent the spaces on the half beam length and each of these spaces will require an equal amount of steel, for the object of using the above method is to space out the beam in such a manner that the average S acting through the middle of each space will be the same, and thus requiring a constant area A_s for as a general practice, the section of metal is kept uniform and the spacing varied.

The first space having been fixed as 5 in., A_s the area of steel for *any space* can be obtained from the formula $A_s = p\,\{(S - bsa) \div aS_s\}$, but the average S at distance p_1 from support is $(\cdot 5l - \cdot 5p_1)w$ (*vide* table, as already discussed), hence substituting this value of S

$$A_s = \{p_1(\cdot 5wl - bsa) - \cdot 5p_1^2 w\} \div aS_s \qquad (15)$$

$$\therefore \; A_s = \{5 \times (50,000 - 10,560) - 8,680\} \div 264,000$$

$$= 0\cdot 72 \text{ sq. in. (by slide rule).}$$

This means four $\frac{3}{8}$ in. diam. **U**-shaped stirrups in any one space giving an area of 0·88 sq. in. (Four $\frac{5}{16}$ in. diam. stirrups would give only 0·61 sq. in.).

[At this stage it is necessary to point out that if *bsa* is neglected altogether, A_s as deduced from the general equation $(pS) \div (aS_s)$ will be the same for any space, as arrived at by the parabolic method, *i.e.* $p_1S_1 = p_2S_2 = p_3S_3$, etc., but if *bsa* is taken into consideration as has been done in the present example, the shear diagram is obviously changed from the perfect triangle to a trapezium (see *Fig.* 4), and this in turn demands a B.M. diagram which would be a slight distortion of the original perfect parabola, further meaning a small increase in each individual space, as already deduced, keeping value of A_s same. At any rate the slight approximate is on the safe side, and as *bsa* becomes more and more negligible as compared to ·5*wl* the small approximation disappears. As stated above if *bsa*, that is the resistance of concrete to shear, is neglected throughout the results are exact.]

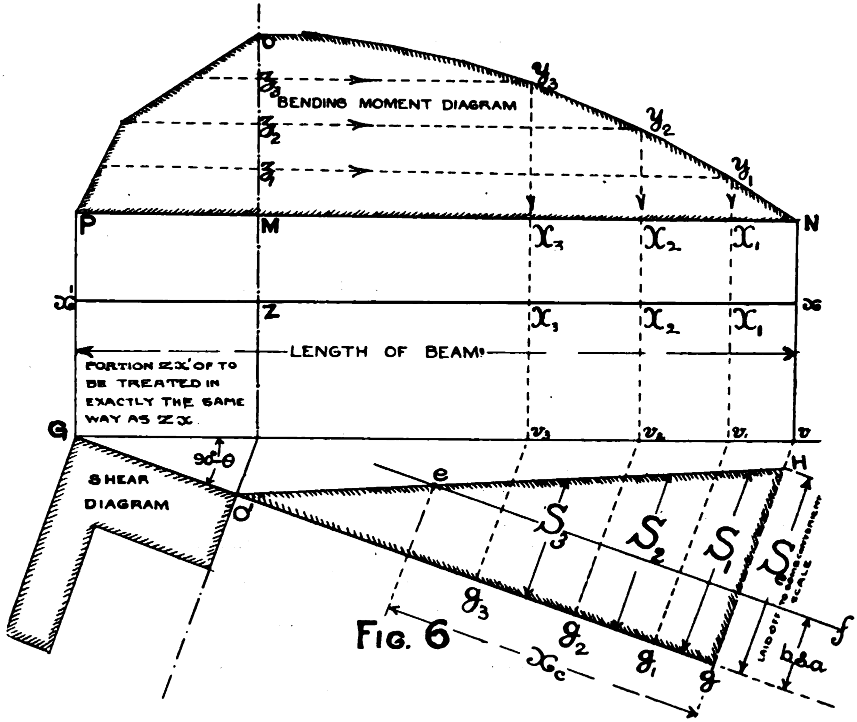


Fig. 6

In the present example there are eight spaces, and hence total area required for whole beam length will be $2 \times 8 \times {\cdot}72 = 11{\cdot}52$ sq. in. as deduced theoretically, as the commercial size of bars would be always adopted, the total area required in actual practice would be $2 \times 8 \times {\cdot}88 = 14{\cdot}08$ sq. in., and it is to meet such contingencies that the value of equation 9 is increased by 25 per cent. (See also equation 14).

If the resistance of concrete to shear is to be taken into account, consider only the spaces lying between x and x_c for reinforcing with steel.

If after making the above calculations it is found that, say, about half of the main tension bars when cranked up supply the requisite area, it means that there is no need for stirrups, but then the engineer in charge at work spot should see that the bars are carefully bent at the required points, etc.

Note should be made that some of the tension bars should also be cranked up near the supports to give continuity from the bottom of the beam to the top, and the top ends of the shear members should also be horizontally bent.

If the angle of inclination is 45°, reduce A_s by multiplying it with ·707. To construct parabolas refer *Lineham's Engineering*, p. 446, *Kempe's Year Book*, p. 43, or any other well-known Engineering Handbook.

If resistance of concrete be not taken into consideration, neglect "bsa" in the various equations. It should be always remembered that during actual construction the human (unskilled) element plays an important part, for no ordinary workman ever fixes the stirrup with mathematical precision as to distance or uses particular care (very often ramming it or jamming it in when the foreman is not looking); hence 50 per cent. more stirrups for the end portions of the beam would not be even out of place. More often than not the initial rupture in a beam is due to lack of, or badly placed, shear members. As a general rule inclined stirrups near to the supports should be placed in such a way that the top end A' of, say, a stirrup $\overset{A'}{\underset{A}{/}}$ is just perpendicularly above the bottom end B of the consecutive stirrup BB', $\overset{B'}{\underset{B}{/}}$.

RAPID GRAPHIC METHOD FOR ANY LOADING AND BEAM.

Let $x'Zx$ represent the effective length of a beam bearing any particular loading. Draw Bending Moment diagram, see *Fig.* 6, which is self-explanatory. Draw $Px'G$ and Nxv two ‖ straight lines perpendicular to $x'Zx$. Choose any point G and draw hrztl. straight line Gv (which will of course be of exactly the same length as $x'Zx$). Project axis Gv upon axis Gg at $\theta°$ inclination (if stirrups are to be inclined at $\theta°$). On Gg construct the shear diagram to some convenient scale (see *Goodman's Mechanics*, pp. 402-421). Calculate b, r, n', a, d, etc., by the usual methods. Decide upon values of s, S_s.

Divide the Max. ordinate MO [BM diagram] into equal parts in such a way that z_1 projected on $x'Zx$ as x_1 (through y_1) does not give the first space from the support > the amounts ·5a or ·25a as the case may be and as already discussed. Project x_1 as v_1 on Gv and v_1 as g_1 on Gg. Measure S_1 the average ordinate between g and g_1; then $A_s = \frac{p_1\{S_1 - bsa\}}{aS_s}$ where $p_1 = xx_1$. Similarly project $z_2\,z_3\,z_4$, etc., as $g_2\,g_3\,g_4$ (*via* $y_2\,y_3\,y_4$ and $v_2\,v_3\,v_4$). The spacing on the beam is given by $xx_1\ x_1x_2\ x_2x_3$, etc. As a check for any space, say p_3, calculate A_s as $A_s = \frac{p_3\,(S_3 - bsa)}{aS_s}$ and this should be nearly same as obtained from $A_s = \frac{p_1\,(S_1 - bsa)}{aS_s}$. (The same remarks made previously with regard to neglecting the quantity bsa and how the presence of this quantity effects the true BM diagram apply here also.) Reinforcement need not be placed any farther than length x_c and x_c can be easily determined as shown in *Fig.* 6. Lay off bsa in lbs. unit (same scale as that used for laying off S_e) and draw fe parallel to gG, cutting HO' in e; then the perpendicular distance of point e from Hg gives the necessary length x_c.

Quick calculation for estimating work. Draw BM diagram (*Fig.* 6). Divide Max. ordinate MO into B equal parts such that z_1 projected on $x'Zx$ as x_1 does not give p_1 > amounts ·5a or ·25a as case may be. Then difference between any two consecutive ordinates x_1y_1 (on BM diagram) and x_2y_2, or x_2y_2 and x_3y_3, or say $x_{n-1}\ y_{n-1}$ and x_ny_n must be the same, and is equal to the difference between the BMs at two vertical sections close to each other, but $\frac{BM_1 - BM_2}{a} = \frac{S_1}{a}p_1$ or $\frac{S_2}{a}p_2$, etc. (see equation 6), thus S for any p can be always found.

Again A_s for any space $= p_1\left\{\frac{S_1 - bsa}{aS_s}\right\}$ or $p_2\left\{\frac{S_2 - bsa}{aS_s}\right\}$ hence total area for whole length of beam $= 2\beta p\left\{\frac{S - bsa}{aS_s}\right\}$ where β = number of spaces in one half length of beam.

OUR CONCRETE COTTAGE COMPETITION.

In this issue we present the designs and specifications to which consolation prizes were awarded, together with a short commentary thereon. In addition we also give some of the other designs sent in with their specifications.—ED.

DESIGN No. 248 is a one-storey cottage with a flat concrete roof, with an original plan, and is thought worthy one of the consolation prizes of £5 5s.

The diagonal treatment with the re-entering angle, in which the door is placed, is not economical, and leads to waste on the plan in the length of the passage; otherwise the arrangement is good and might suit the views of some to whom cost is not the first consideration, and the aspect of the windows is excellent.

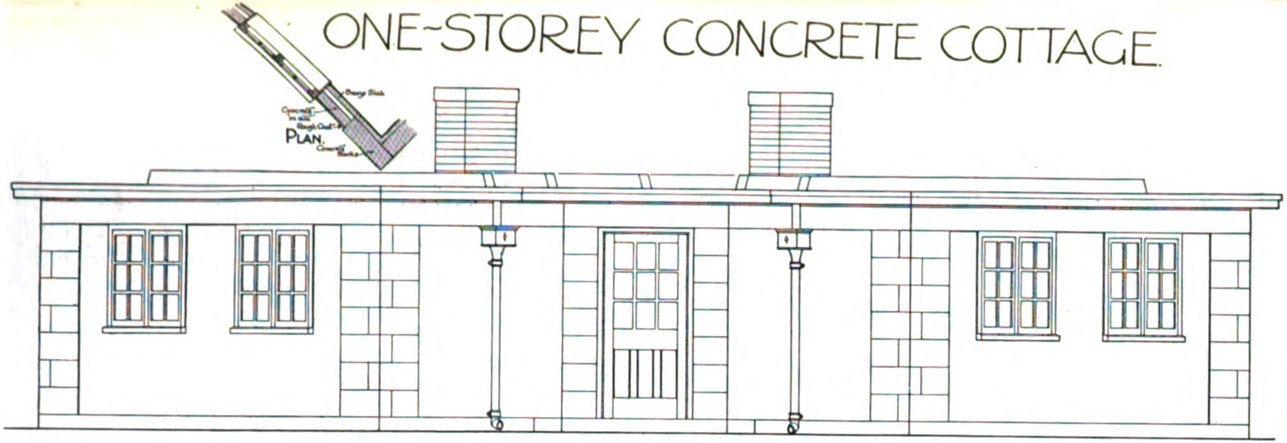
The living room is 156 ft. in area, the scullery 67 ft. in area, and the three bedrooms 142 ft., 109 ft. and 82 ft. in area respectively, all 8 ft. high. A good store, receptacle for fuel, and W.C. are all provided under the roof of the main building. The cube is given as 8,558 ft., which is the largest amongst the selected designs, and the price, 3½d. per cubic foot, is below what the work might be expected to be carried out for. At this price the cost would be £125.

Another design which comes in for a consolation prize is No. 129, constructed entirely of concrete. A two-storey pair of cottages, the pair to stand isolated, each having a living room, scullery and bedroom on the ground floor, and two bedrooms on the first floor. The food cupboard is in the house, but the fuel store and W.C. are in a small projecting wing at the back.

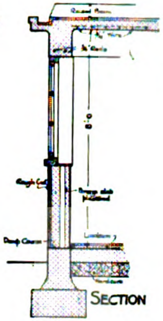
The living room is 148½ ft. in area, the scullery 60 ft. in area, and the ground-floor bedroom 66½ ft. in area. One bedroom on the first floor is 140 ft. and the other 107½ ft. in area. There are two cupboards entered from one of the bedrooms, which is a very great convenience in a house of this description. As a rule accommodation for clothing is conspicuous by its absence.

The ground-floor rooms are about 8 ft. 2 in. high, and those on the first floor 8 ft. 6 in. high. The cube for the pair is given as 14,090 ft., and the estimated cost is £249 9s. 3d., this being about 4½d. per ft. cube.

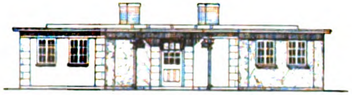
ONE-STOREY CONCRETE COTTAGE

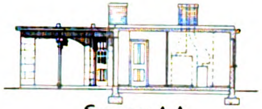

PLAN.

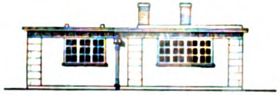
HALF-INCH DETAIL

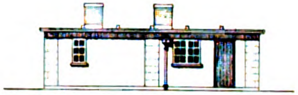


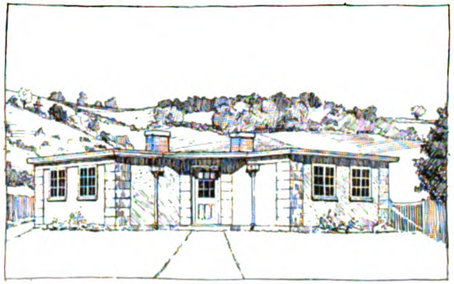
SECTION

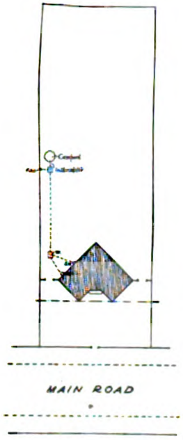

WEST ELEVATION


SECTION A.A.


S.E. ELEVATION

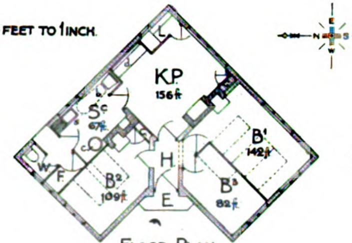

N.E. ELEVATION


PERSPECTIVE SKETCH.

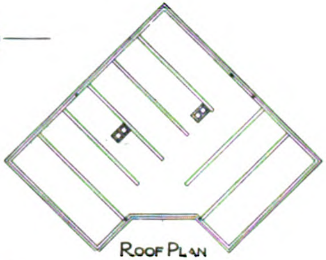


SITE PLAN
32 FEET TO 1 INCH.

8 FEET TO 1 INCH.



FLOOR PLAN


ROOF PLAN

ROOM	REF.	LENGTH	BREADTH	AREA	HEIGHT	CONTENTS
LIVING RM.	K.P.	14'-0"	11'-0" av.	156 ft. sup.	8'-0"	1248 ft. cu.
SCULLERY	Sc	9'-0"	7'-6"	67 "	8'-0"	536 " "
BED ROOM	B¹	15'-0"	9'-0"	142 " "	8'-0"	1136 " "
BED ROOM	B²	12'-6" av.	8'-6"	109 " "	8'-0"	872 " "
BED ROOM	B³	11'-6" av.	7'-0"	82 " "	8'-0"	656 " "

CUBIC CONTENTS:—
11'0"(31'-0"+13'-6")×17'-6"= 8558 ft. cu.
@ 3½d. = £125.

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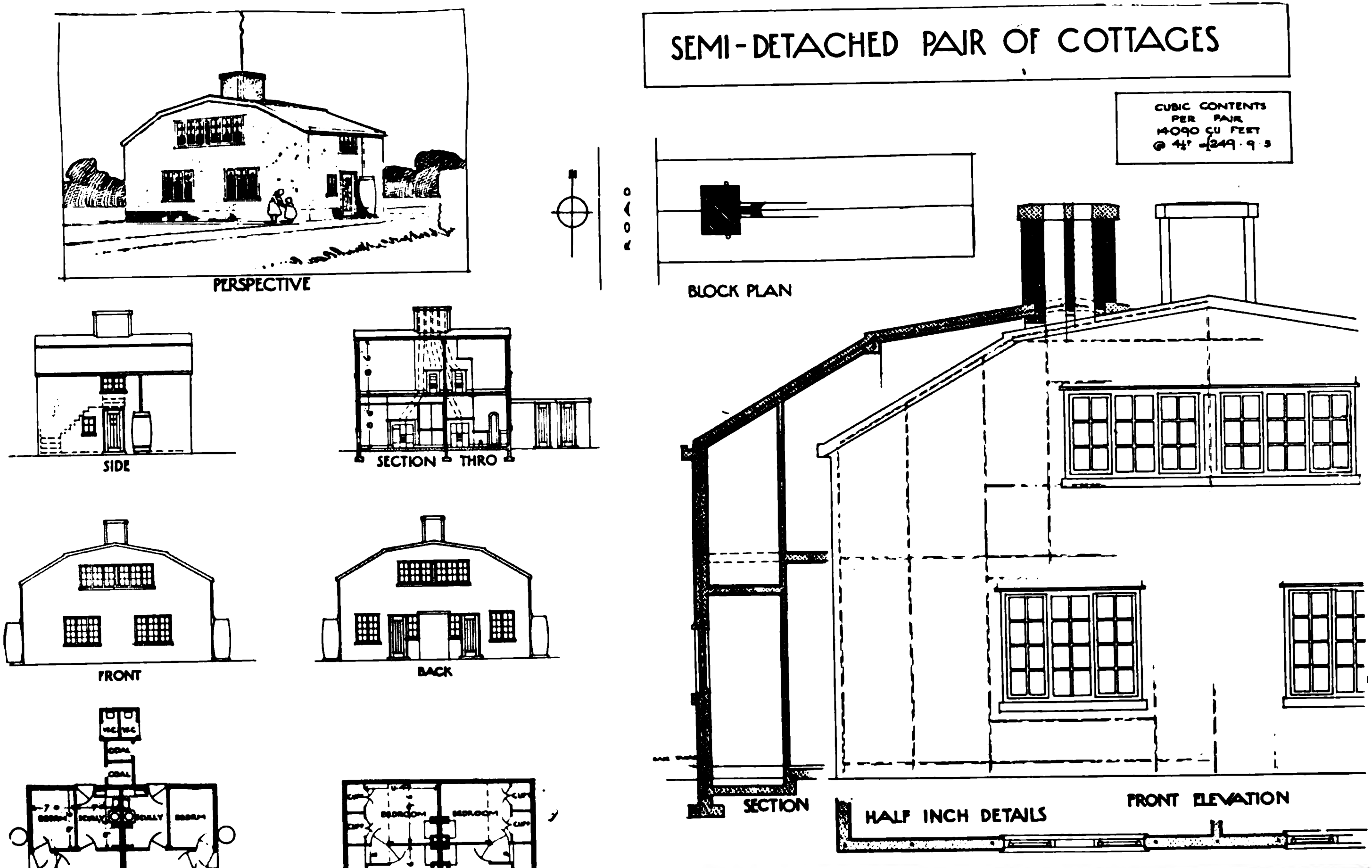
CONSOLATION AWARD. DESIGN NO. 248 ... BY E. W. STUBBS A.R.I.B.A.



NOTE: EXTERNAL WALLS & ROOF, CONCRETE REINFORCED WITH STEEL BARS, ALSO FLOORS, PIER INSIDE PORTION OF PARTY WALL, STAIRS & STEPS. THE CONCRETE ROOF TO BE COATED WITH PITCH AND TAR AND DUSTED WITH FINE SPAR CHIPPINGS AS THE ROOFS HAVE A SLOPE, THE RAINWATER RUNS AWAY QUICKLY, THIS TREATMENT WILL ENSURE A WATERTIGHT COVERING. THE FIREPLACES ON BOTH FLOORS TO BE IN BRICKWORK OR BRICKLINED; THE CHIMNEY STACK TO BE IN BRICKWORK SKIMMED EXTERNALLY WITH CEMENT & HAVING A CONCRETE CAPPING ON TOP

THE INTERNALS WALLS OR PARTITIONS TO BE OF 2½" PATENT CEMENT SLAB PARTITIONS REINFORCED WITH RODS
THE W.C.S AND COALPLACES AT THE BACK TO HAVE A FLAT CONCRETE ROOF TREATED AS DESCRIBED ABOVE
DOORS AND FRAMES WINDOW FRAMES TO BE OF RED DEAL PAINTED
ALL FLOORS WITH THE EXCEPTION OF LIVING ROOM WHICH IS FINISHED WITH WOOD BLOCKS TO HAVE 1" GRANOLITHIC FINISH. THE STAIRS TO BE SIMILARLY FINISHED AND WITH ROUNDED NOSING TO TREADS
SINKS WASH BOILER TOP & SIDES, GUTTERS, CAST IN CONCRETE
EXTERNAL WALLS TO BE ROUGH CAST & DASHED ROOF & WALLS ARE IN AS FEW PLANES AS POSSIBLE

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CONSOLATION AWARD. DESIGN NO. 159 … By MESSRS. COCKER & HILL, A.A.R.I.B.A.

SPECIFICATIONS TO THE DESIGNS.

GENERAL DESCRIPTION.

With Design No. 248 (By E. W. Stubbs, A.R.I.B.A., Grayshott, Marlborough Road, South Croydon).

This cottage has been designed to provide a compact and convenient plan with the minimum of waste space, whilst retaining an ample amount of light and a suitable aspect in all the rooms.

The one-storey plan gives the maximum of floor space in proportion to the amount of external wall, and has the advantage of saving the space occupied by the stairs.

The outer walls are to be built with panels of "in situ" concrete, the piers shown being first built with concrete blocks and serving as a support for the necessary shuttering.

The panels are afterwards to be finished with rough-cast externally, and to prevent condensation the internal face of wall is to be lined with 2-in. breeze concrete slabs finished with a setting coat of plaster, leaving a 2-in. cavity as shown.

The roof is to be of concrete with beams on the upper surface, and is to be finished with cement rendering waterproofed with Pudlo. The reinforced lintels are to be continued round the whole building, and the roof is to overhang the entrance to form a shelter.

Access to the w.c. and fuel store is by a covered lobby. The two chimneys required are to be of brick, the fireplaces being all arranged on internal walls to avoid loss of heat.

The flues are to have slabs of concrete as shown over the fireplace openings to prevent down-draught.

Excellent bedroom accommodation has been made a feature of the plan, the areas shown being the actual floor areas exclusive of chimney breasts, cupboards, etc.

Specification.

Foundations are to have bed of concrete 2 ft. wide and 12 in. deep composed of 1 part Portland cement to 6 parts clean ballast. Walls below damp course to be of similar concrete filled in between shuttering. Damp course to be 1 : 3 cement mortar 1 in. thick.

Piers shown are to be built with concrete blocks made with concrete composed of 1 part Portland cement, 2½ parts sand, and 5 parts gravel to pass a ¾-in. mesh. Blocks to be 2 ft. by 12 in. and 1 ft. 5 in. by 12 in., and all 7 in. on bed.

The panels between piers to be moulded in position 4 in. thick with concrete as last filled in to shuttering cut between piers and held in position by bolts and distance pieces. The lintel round top of building to be moulded in position with similar concrete and reinforced with two ¾-in. rods. Construct the roof with concrete as last 4 in. thick to slight falls and reinforced with expanded metal.

Form raised beams as shown, reinforced with two ¾-in. rods to each. Finish roof with cement and sand 1 : 3, waterproofed with Pudlo. Form overhanging eaves and gutter as shown and put 3 in. r.w.p. and heads, rain water to be taken to soakaway or concrete tank.

The fireplaces and chimneys are to be built with Fletton bricks in cement with proper footings on 12-in. concrete bed of required width. Put to all fireplace openings concrete lintels and baffle slabs as shown. Finish chimneys at top with concrete caps 6 in. thick, perforated for flues, and carry rendering round base of chimneys where they pass through roof.

Strip off vegetable soil over site of building and replace with 6-in. bed of clean hard core well rammed down.

Form floor with 4-in. bed of 1 : 6 concrete as before, the bedroom floors to be finished fair face to receive linoleum, and all other floors to be finished in cement and sand 1 : 3.

Line walls internally with slabs of breeze concrete 2 in. thick set in cement and secured as directed.

Build internal partitions as shown with similar blocks and finish throughout with setting coat of plaster.

The internal doors are all to be the same height and of two standard widths, and are to be 1½-in. four-panel doors hung in 3 in. by 3 in. solid frames, the entrance door to be 1¾-in. glazed door, as shown, with 4 in. by 3 in. frame.

The windows are all to be the same height and of four standard widths, and are to have 4-in. by 3-in. rebated deal frames, 6-in. by 3½-in. sunk and weathered oak sills, and 1¾-in. moulded casements glazed with 15 oz. sheet glass. Finish round windows internally with ¾-in. jamb linings and 1-in. rounded window board.

Bedrooms are to have 1½-in. by 1½-in. chamfered floor fillet, and other rooms are to be finished with cement skirting 6 in. high.

Knot, stop, prime and paint three coats on all woodwork where exposed, paint all ironwork three coats, twice distemper walls and partitions internally, and whiten ceilings.

The centering for the roof is to be wrought, and the whole of the centering and shuttering can be used several times if a number of cottages be built.

List of Fittings and P.C. Prices.

	£	s	d.
Living Room.			
Portable Range from the Carron Company	2	10	0
Dresser to fit recess as shown	2	0	0
Scullery.			
Small Stove to enable cooking to be done in summer without using range	1	0	0
Carron Co.'s Portable Copper to hold 12 gals.	2	0	0
Folding Bath, 5 ft. long, P.C. £3 10s. (not included), fitted in recess as shown, with waste discharging over sink gulley.			
Sink, as shown, of moulded concrete, with wood Draining Boards.			
Two tiers Shelving.			
Larder.			
Lower Shelves to be concrete slabs, Upper Shelves 1-in. deal	1	0	0
W.C. to have pedestal wash-down apparatus, complete with Flushing Cistern, Seat, etc., P.C. £2.			
Bedrooms.			
All to have Mantel Register Stoves, P.C. 10s.	1	10	0
Total	£10	0	0

Estimate of Cost.

Note.—The quantities below have been arrived at by careful measurement.

		£	s.	d.
Excavating		2	10	0
Hard Core		1	10	0
Concrete:				
6 : 1 Ballast Concrete in Foundations, etc.	27 yds.			
5 : 2½ : 1 Gravel Concrete in Walls and Roof	32 yds.			
5 : 1 Breeze Concrete in Slabs	6 yds.			
Total	65 yds.			
The following materials are required for the above Concrete:—				
32 yds. Ballast @ 3s.		4	16	0
28 yds. Gravel @ 4s.		5	12	0
14 yds. Sand @ 5s.		3	10	0
7 yds. Breeze @ 4s.		1	8	0
12 tons 8 cwt. Portland cement @ 35s.		24	14	0
Labour, mixing and handling 65 yds. concrete @ 3s.		9	15	0
Steel, 6½ cwt. ⅜-in. rods @ 9s.		2	19	0
Expanded Metal, 100 yds. @ 9d.		3	15	0
Centering		10	0	0
Pudlo		0	10	0
Cement Rendering and Rough-cast		10	0	0
Plastering		5	0	0
Distempering		2	0	0
Brickwork		8	0	0
Doors and Frames		9	0	0
Windows and Glazing		9	0	0
Painting		2	0	0
Fittings and Sundries		12	0	0
Total		£124	19	0

With Design No. 129 (By Messrs. Cocker & Hill, A.A.R.I.B.A., 20 Station Buildings, Altrincham).

Description of Design.—The plan is so arranged that there is very little traffic through the living room, and a maximum of bedroom space upstairs.

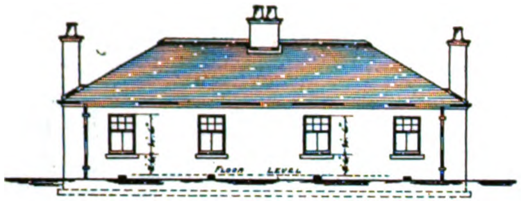
The coal-places and w.c.'s are placed together, so that as little of the back garden space is taken up as possible.

The external walling is straight and simple, so that it may be quickly and easily built. The concrete roof is in flat, simple surfaces and slightly sloped, so that the water may get quickly away. This treatment helps to do away with the box effect associated with a flat roof on a plan of this kind.

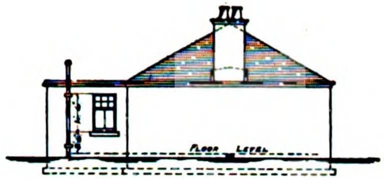
Materials.—External walls and roofs, floors and piers inside, to be Portland cement concrete reinforced with steel bars. The internal walls and partitions are of patent cement slabs, and are joined to the walls, etc. The roof to be covered with pitch and tar, and dusted with fine spar.

The surface of the external walls to be dinged, or rough-cast and dinged.

The windows and doors, and frames to same, to be red deal painted.



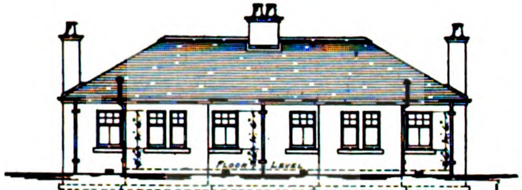
— BACK ELEVATION. —



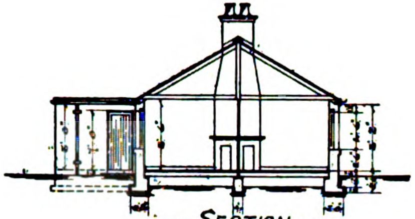
— SIDE ELEVATION. —

LIST OF ROOMS IN ONE COTTAGE.				
ROOMS	DIMENSIONS	SUPER AREA	HEIGHT	CUBIC CONTENTS
K.P.	14' 0" × 11' 2½"	150'	8' 6"	1275'
Sc.	8' 2" × 5' 6"	44	8' 0"	352'
B	12' 2½" × 11' 2½"	125'	8' 6"	1072½
B.	11' 2½" × 10' 6"	120'	8' 6"	1020'
B.	11' 2½" × 8' 8½"	94'	8' 6"	799'
L.	3' 11½" × 2' 10"	11'	8' 0"	88'
C	3' 0" × 1' 0"	3'	7' 0"	21'
W.	3' 11½" × 2' 10"	11'	8' 0"	88'

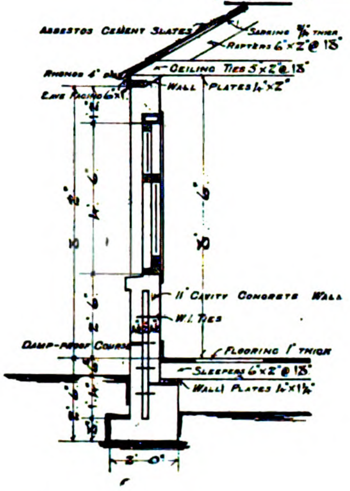
CUBIC CONTENTS OF ONE COTTAGE
9960 FEET.

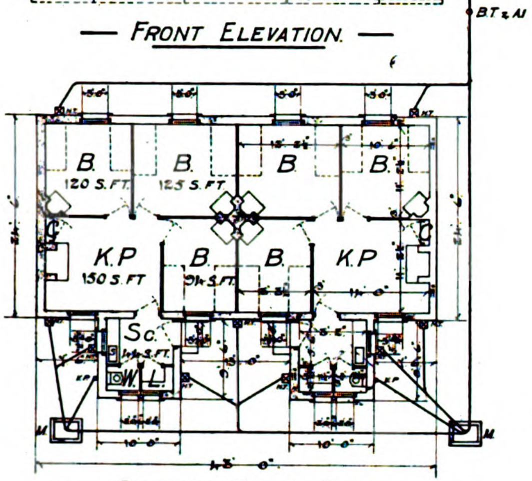


— FRONT ELEVATION. —

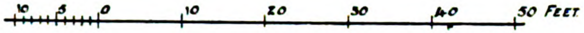


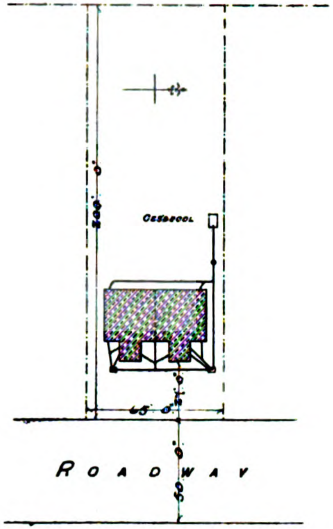
— SECTION. —





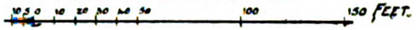
— GROUND FLOOR PLAN. —





— SITE PLAN. —

SCALE FOR SITE PLAN 1/32" = 1 FOOT



DESIGN NO. 16 ... BY J. ARTHUR SMITH, ARCHITECT.

All floors, with the exception of living-room, which is finished with wood blocks, to have 1-in. granolithic finish; also the stairs, the latter to have a rounded nosing to the treads.

Sinks, wash boiler top, and sides, gutters, cast *in situ* in Portland cement concrete.

The concrete walls to be of best and carefully selected materials and mixed in the following proportions :—

1 of Portland cement.
1½ of sand.
4 of broken bricks.

The cubical contents of the pair is 14,090 cu. ft., measured from bottom of footings to half-way up the rake of the roof.

Cost.—This contents, priced at 4½d. per cu. ft., which should pay for grates, brings the cost to £249 9s. 3d.

With Design No. 16 (By J. A. Smith, The Highland Railway Engineers Department, Inverness).

THIS design is suitable for detached or semi-detached labourers' cottages, or it could be built in blocks of four or more as the occasion required. The cottages are to be built of concrete, the walls being 11 in. thick cavity walls, rock faced and cement pointed on the outside, the partitions being of concrete slabs 2 in. thick and with plaster applied directly on the inside of the concrete walls and both sides of the partitions, the main roofs being slated with grey asbestos cement slates with concrete ridging, and roofs of scullery wings being of concrete 4 in. thick. The sills, lintels, hearths, door platts, chimney stalks and coping, and floors of sculleries, larders, and w.c.'s being all of concrete.

Each cottage contains the following accommodation, viz. :—Combined living room and kitchen 14 ft. by 11 ft. 2½ in., scullery 8 ft. 2 in. by 5 ft. 6 in., three bedrooms respectively 12 ft. 2½ in. by 11 ft. 2½ in., 11 ft. 2½ in. by 10 ft. 6 in., and 11 ft. 2½ in. by 8 ft. 8½ in., larder, cupboard, or press, and w.c.

All the rooms are on one floor, thus saving the expense of stairs.

All the bedrooms have each a fireplace.

No space is wasted with passages or lobbies.

Specification.

Excavate surface earth over area of cottages and trenches for foundations to depth shown and levelling same on site.

Floor level of cottages to be 6 in. above the level of finished ground surface.

Foundations for external walls and chimney stalks to be of cement concrete 6 in. to 18 in. thick.

Damp-proof course of Callender's bitumen pitch and tar run on hot, above floor level in outer 4½-in. wall and below wall plate in inner 9-in. wall.

External walls to be built hollow in two 4½ in. thicknesses of cement concrete blocks 6 to 1 with 2 in. space between, bonded together with 1¼-in. by ¼-in. twisted and forked W.I. tie irons dipped in tar or galvanised, spaced at intervals not exceeding 32 in. laterally and every alternate course.

Chimney stalks to be of cement concrete 6 to 1, having living room fireplaces 3 ft. by 3 ft. 6 in. high, and bedroom fireplaces 1 ft. 9 in. by 2 ft. 9 in. high formed, having 9-in. by 9-in. flues.

Internal face of walls to be roughed for plaster and external face to be in imitation of rock-faced stonework.

Beds and joints to be flushed with cement mortar and the exposed facework to be neatly pointed and keyed.

Louvre gratings 9 ft. by 6 in., and ventilation openings to be put in where shown.

Checks for window cases and door frames, window and door sills and lintels, including mullions to be formed in concrete 4 to 1.

Chimney coping 6 in. thick to be of concrete 4 to 1 with splay on upper angle and moulded on edges.

Terra-cotta chimney cans 18 in. high with bead on top.

4½ in. extra thickness of concrete walls to form scarcement to sleeper walls to receive joists.

Sleeper walls 12 in. thick in cement concrete 6 to 1.

Partitions to be formed in breeze concrete slabs 2 in. thick.

Concrete hearths 4 to 1 to fireplaces and door platts.

Flat roof of scullery wings to be in reinforced concrete. Concrete laid on temporary boarding.

Concrete floors of sculleries, w.c.'s, and larders to be 6 to 1, 3 in. thick laid on bed of hard material and finished with ½-in. coat of sand and cement 1½ to 1.

Door posts, outside and inside doors, and windows to be of redwood. Sleepers, flooring, roofing and all other timber to be of whitewood.

Sleeper joists 6 in. by 2 in. at 18 in. apart from centres laid on wall plates 4 in. by 1¼ in., and covered 1-in. thick grooved and tongued flooring in 5-in. widths, with mitred boards round hearths.

Roofing rafters 6 in. by 2 in., ceiling ties 5 in. by 2 in., and king ties 5 in. by 2 in. set at 18 in. apart from centres on wall plates 4 in. by 2 in., and covered with half checked sarking ¾ in. thick.

Ridge plates 7½ in. by 1¼ in., and piend rafters 7½ in. by 2 in.

Redwood eave facings 6 in. by 1 in. splayed on lower edge. Windows framed and cased and sashes double hung.

Outside door frames 5½ in. by 2½ in., inside door frames 4½ in. by 2½ in., and Press door frames 4 in. by 1½ in. Door posts and lintels in partitions 4½ in. by 3 in., checked for doors, grooved on back 2½ in. by ½ in. to take concrete slabs and arrises rounded.

Outside doors framed 1¾ in. thick and lined, hung on 6-in. edge hinges, having plain stops 4 in. by ¾ in. and plain facings 3 in. by ⅝ in. inside.

Inside doors of plain deal ⅞ in. thick linings on three backings 7 in. by 1¼ in. and hung on 12-in. japanned iron T hinges.

Allow £1 10s. for locks to doors.

Plain facings 3 in. by ⅝ in. to inside doors.

Plain skirting 4 in. by ¾ in.

Three tier of shelving 12 in. by 1 in. thick in each larder and 12 lineal ft. in each living room. One dozen brass utensil hooks on plain belting 4 in. by ¾ in. in each living room.

Japanned iron coat hooks to inside of all bedroom doors.

Box wall press with four shelves.

Mantel shelf 8 in. by 1¼ in. for living-room fireplaces.

Perforated brass ventilating plate 12 in. long fitted into top of each larder door.

Main roof to be slated with grey 15¾-in. by 15¾-in. Ægis asbestos cement slates laid diagonally with 2¾-in. lap, fixed with sherradised or copper nails, and finished with concrete plain lining, set and flushed with cement.

Lath and two coats of Sirapite plaster on ceilings of main building.

One coat of Sirapite plaster on all inside concrete walls, partitions on both sides and underside of flat concrete roof of scullery wings.

No. 13 zinc flashings 8 in. wide at sides and 10 in. wide at front of chimney stalks.

No. 13 zinc gutters at end chimney stalks.

4-in. diameter semicircular eave gutters jointed with red lead and bolted, hung on galvanised wrought-iron straps to main building, and brackets at flat roof of scullery wings having rain water pipes 2½ in. diameter.

Windows glazed with 21-oz. sheet glass, three coats of oil paint to outside and inside woodwork and two coats of oil paint to outside ironwork.

Ceilings whitewashed and two coats of Hall's distemper in selected tints to walls.

Blackening cast-iron mantel registers in bedrooms, also concrete jambs and lintels, sides and backs of living-room fireplaces.

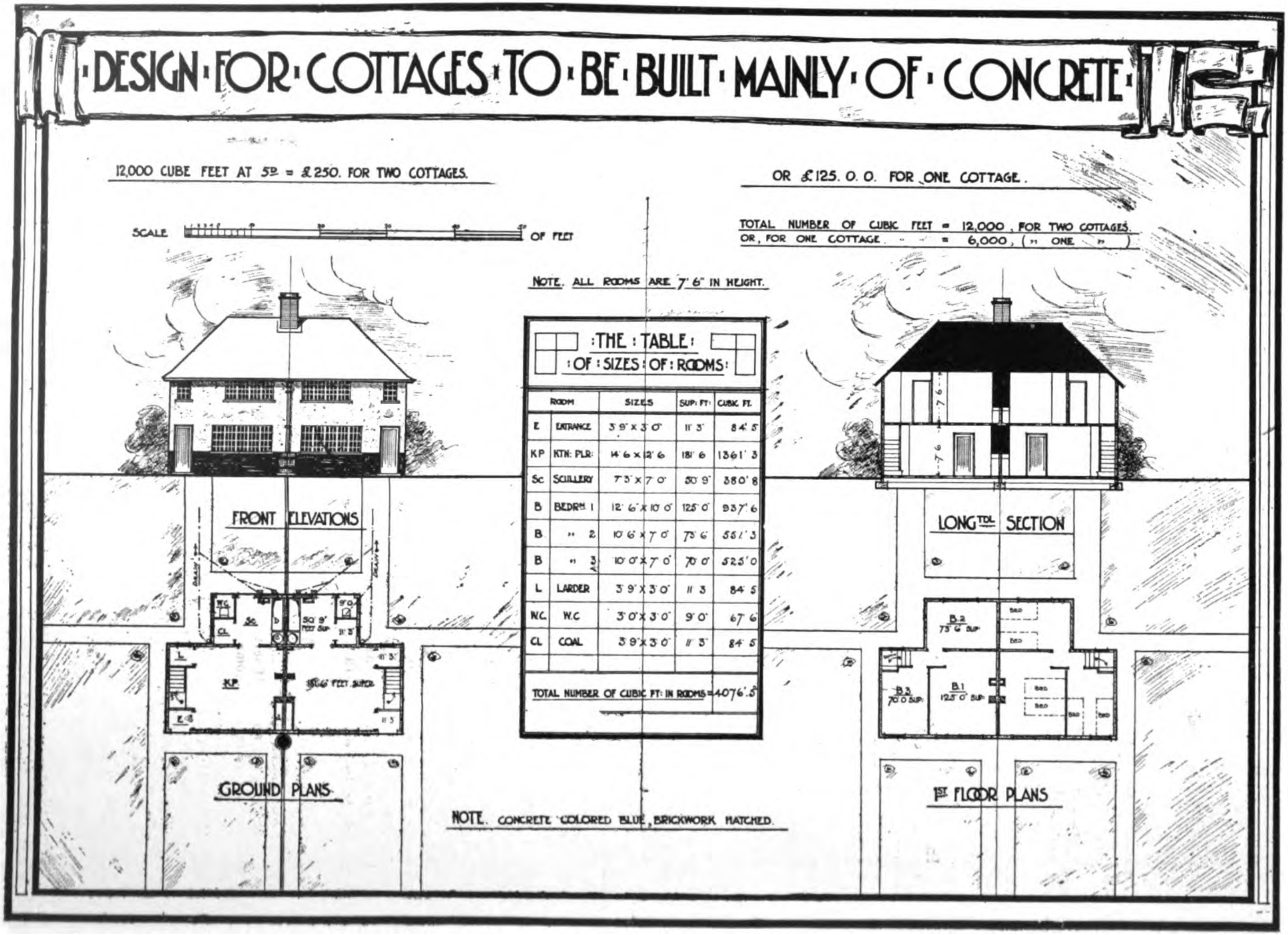
Method of Execution.—Concrete blocks to be made with the "Winget" or other suitable machine, properly seasoned and built in cement mortar. The blocks for face work to be made in moulds to imitate rock-faced stone work.

List of Fittings for each Cottage.

	£	s.	d.
Door Locks	1	10	0
Self-acting and Self-setting Open-fire Range, with oven and hotplate, hobs 24 in. high all complete, 36 in. wide, supplying and setting complete in each living-room	1	16	0
Three Mantel Registers, with fret, 30 in. by 39 in. by 14 in. Fire with double shelf, supplying and setting complete in each bedroom	1	16	0
Shelving, Belting and Utensil Hooks in each living-room	0	7	0
Box Wall Press, Door and Frame, Facings and Lock	1	10	0
Coat Hooks on bedroom doors	0	1	6
Ventilating Plate for larder door	0	1	6

Statement of Cost.

The estimated cost of one cottage based on the cubical contents (9,960 cu. ft. at 3d. per ft.) is £124 10s.—say, £125.



·DESIGN·FOR·COTTAGES·TO·BE·BUILT·MAINLY·OF·CONCRETE·

12,000 CUBE FEET AT 5D = £250. FOR TWO COTTAGES.

OR £125. 0. 0. FOR ONE COTTAGE.

TOTAL NUMBER OF CUBIC FEET = 12,000, FOR TWO COTTAGES.
OR, FOR ONE COTTAGE . . . = 6,000, („ ONE „)

NOTE. ALL ROOMS ARE 7' 6" IN HEIGHT.

:THE : TABLE:
:OF : SIZES : OF : ROOMS:

ROOM		SIZES	SUP: FT:	CUBIC FT.
E	ENTRANCE	3' 9" × 3' 0"	11' 3"	84' 5
KP	KTN: PLR:	14' 6 × 12' 6	181' 6	1361' 3
Sc	SCULLERY	7' 3" × 7' 0"	50' 9"	380' 8
B	BEDRM 1	12' 6" × 10' 0"	125' 0"	937' 6
B	„ 2	10' 6" × 7' 0"	73' 6"	551' 3
B	„ 3	10' 0" × 7' 0"	70' 0"	525' 0
L	LARDER	3' 9" × 3' 0"	11' 3	84' 5
W.C.	W.C	3' 0" × 3' 0"	9' 0"	67' 6
CL	COAL	3' 9" × 3' 0"	11' 3"	84' 5
TOTAL NUMBER OF CUBIC FT: IN ROOMS =				4076'.5

NOTE. CONCRETE COLORED BLUE, BRICKWORK HATCHED.

DESIGN NO. 53 .. BY HORACE JONES.

Cubic Contents of one Cottage.

24 ft. 0 in. × 24 ft. 6 in. × 15 ft. 0 in. = 8,820 cu. ft.
10 ft 0 in. × 9 ft. 6 in. × 12 ft. 0 in. = 1,140 cu. ft.

9,960 cu. ft.

Probable Estimate of Cost of one Cottage.

	£	s.	d.
Concrete Work	54	19	0
Carpenter and Joiner Work	40	15	11
Slater Work	8	12	6
Lath and Plaster Work	6	11	1½
Plumber Work	5	3	10½
Painter and Glazier Work	5	5	7
Range and Grates	3	12	0
	£125	0	0

With Design No. 53 (By Horace Jones, 7 Berwick Street, Eccleston Square, S.W.)

Description of Buildings.

THE cottages are intended to be built of concrete, finished with cement and pudlo, and the roofs to be covered with Eternite red tiles.

From the ground line to top of ground floor window sills will be twice tarred.

The windows to be casements in solid frames, part fixed and part hung, and divided up into small squares.

Doors to be framed, ledged and braced, or ledged doors as hereafter described.

The chimney breasts and stack to be built in brickwork.

Painting to be three-coat work.

Realising that there cannot be much scope for decoration and originality of design for the money to be spent, the author has endeavoured to rely on simplicity to make the cottages effective.

Specification.

Excavator.—The ground to be excavated for footings until an approved bottom is found.

The surplus earth to be spread at the back of site as directed.

Concreting.—The concrete for foundations to be composed of four parts of hard broken bricks and stone (broken to easily pass a 2-in. ring), one part of approved gravel and sand, and one part of Portland cement. First mixed dry, watered, well turned over again, and then thrown into trenches whilst fresh and well rammed with a rammer.

The concrete for walls to be composed of four parts of hard stone and brick (broken to easily pass a 1-in. ring), one part of Bideford or other approved gravel, and one part of approved Portland cement, which will have to stand test. The admixture to be turned over twice dry and once wet and used fresh.

No concrete that has been mixed more than half-an-hour will be allowed.

All materials for concrete to be measured by a proper gauge-box.

The concreting must be done in stages, for which approved shuttering is to be firmly and strongly fixed; and no shuttering is to be pulled down until twenty-four hours after the whole of the necessary height is completed.

Reinforcement.—¾-in. iron bars or angle iron will be inserted in the concrete, as it is being done, over windows and doors 6 in. longer than the opening at each end; also down the sides of openings for windows and doors; and all the iron to be entirely embedded in the concrete at least 3 in. all round.

Expanded metal sheeting No. 10 gauge 3-in. mesh will be used as reinforcement to the first floors.

Windows and Doors.—The windows to be 1¾-in. casement sashes divided into small squares in 4-in. by 3-in. solid frames and mullions, part hung; 7-in. by 3-in. sills with small mould planted under.

The front doors to be framed, ledged and braced doors in 4-in. by 3-in. solid frames; other doors to be ledged.

Brickwork.—Brickwork to be in hard, well-burnt approved stocks in mortar.

Floors.—*Ground Floor:* To be in 4-in. concrete composed as described for foundations, finished with ¾-in. thick cement, trowel finished. *First Floor:* To be 5-in. coke breeze concrete, 4 to 1, and to have expanded metal sheeting (as before described) embedded in same; finished with 1-in. white flooring.

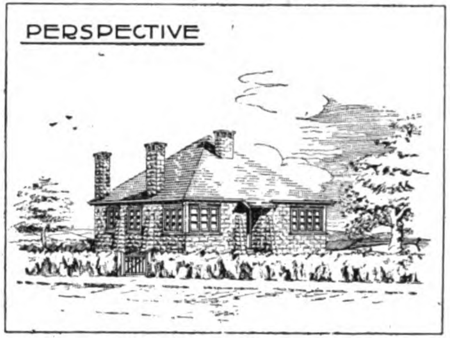
Roofs.—To be constructed 9-in. by 2-in. hips, 9-in. by 2½-in. purlins, 7-in. by 1-in. ridge, 3-in by 2-in. common rafters, and 3-in. by 2-in. ceiling joists.

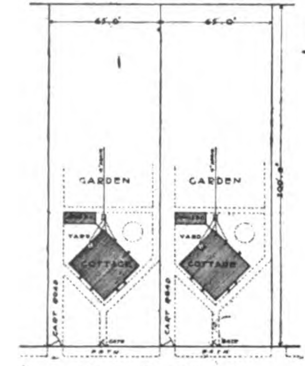
DESIGN FOR DETACHED COTTAGE

TABLE	DIMENSIONS	AREA	HEIGHT	CUBIC CONTENTS
LOBBY & HALL	3'.6' X 16'.3'	56'.10'	8'.6'	483'.0'
COMBINED LIVING ROOM & KITCHEN	13'.0' X 15'.0'	195'.0'		1657'.6'
SCULLERY	9'.3' X 6'.6'	60'.1'	·	510'.8'
BEDROOM (LARGE)	13'.3' X 10'.0'	132'.6'	·	1126'.3'
BEDROOMS (SMALL)	10'.0' X 9'.0'	90'.0'		765'.0'
BATHROOM	4'.0' X 9'.4'	37'.4'	·	317'.4'
LARDER	5'.6' X 2'.6'	13'.9'	·	116'.10'
W.C.	5'.6' X 3'.0'	16'.6'	·	140'.3'

CUBIC CONTENTS OF BUILDING 11756'.0' AT 2½ᴰ

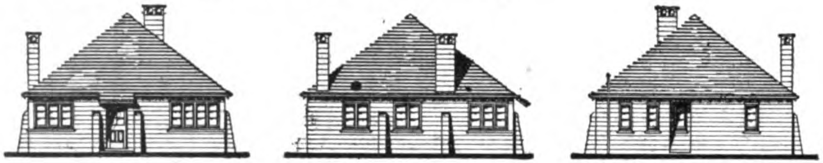
COST £122.9.2.

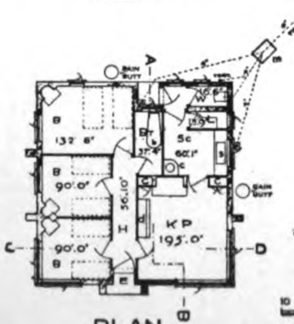




BLOCK PLAN

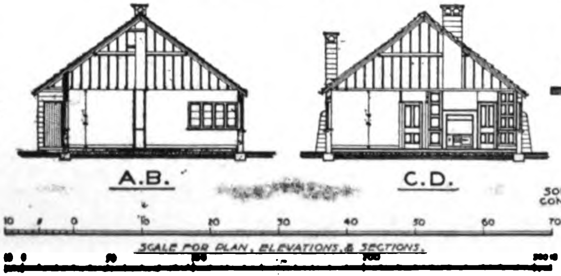
ELEVATIONS

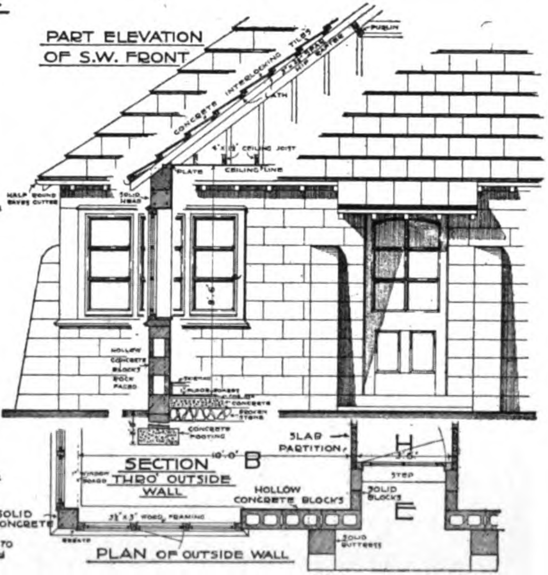




PLAN

SECTIONS





A DETAIL.

DESIGN No. 105 ... BY SYDNEY WALTON.

Plastering.—To be rendered and set in lime putty to the whole of the inside wall surfaces.

Stucco.—Render in cement and sand and finish with cement and pebble dash to whole of exterior walls, and pudlo and whitewash on completion.

Glazier and Painter.—The glass to be 21-oz. British clear sheet free from defects and to approval.

The painting to be done to selected colours and all to approval. To be three coats in addition to the priming and well rubbed down after each coat.

Hearths.—To be floated up in cement.

Partitions.—The partitions to rooms to be "Hercules" or other approved concrete partition slabs.

List of Fittings and Nett Prime Cost of Same.

	£	s.	d.
One grate, p.c. 20s.	1	0	0
One range, p.c. 80s.	4	0	0
Eight pair Butts (2½-in butts to all sashes to open), p.c. 3d. pair	0	2	0
Six pair Hinges (16-in. "T" hinges to doors), p.c. 7d. pair	0	3	6
Nine Casement Stays, p.c. 9d.	0	6	9
Nine Casement Openers, p.c. 9d.	0	6	9
Six Norfolk Latches, p.c. 1s.	0	6	0
Four Bolts (to outside doors), 6 in., p.c. 6d.	0	2	0
Three 4-in. Bolts to bedroom doors, p.c. 6d.	0	1	6
One Night Latch to front door, p.c. 4s.	0	4	0
One Dresser, p.c. 75s.	3	15	0
One Bath (not included in estimate)			
One Copper. Ditto.			
One Sink. Ditto.			
One W.C. Ditto.			
Total for One Cottage,	£10	7	6

How Cost was Arrived at.

			£	s.	d.
1.	17 ft. 0 in.×13 ft. 0 in. (main)×20 ft. 4 in.	4,493 ft. 8 in.			
	10 ft. 9 in.×7 ft. 0 in. (outbuilding)×20 ft. 4 in.	1,505 ft. 10 in.			
		5,999 ft. 6 in.			
	6,000 cu. ft. at 5d. per cu. ft.		=£125	0	0
			£	s.	d.
2.	Excavator and Concretor (Foundations)		8	15	0
	Constructional Concreting		43	15	0
	Tiler		10	0	0
	Carpenter and Joiner		36	10	0
	Plasterer		10	0	0
	Painter and Glazier		7	5	0
	Smith and Founder		8	15	0
			£125	0	0

With Design No. 105 (By S. Walton, Buxton, Derbyshire).

Descriptive Specification.

Description of the Building.—The accompanying design illustrates a proposed detached cottage to be erected in a series of six.

It is proposed to place the building anglewise on the plot to give the living-room the maximum of sunlight.

The accommodation is provided on one floor on account of economy and compactness, and comprises front and back (indirect) entrances, hall or passage, combined living-room and kitchen, scullery, bathroom, larder, w.c., principal bedroom (adults'), and two bedrooms (male and female children).

The block plan shows suggested position of a coal and tool store and yard, but the provision of these is not included in the total cost; they would probably be wood structures provided by tenant.

The required floor areas of principal rooms are provided, and the plan is compact without being cramped. All rooms are 8 ft. 6 in. high from floor to ceiling.

A half-inch scale detail is given showing the proposed treatment of walls, floors, foundations, roofs, joinery, etc.

A perspective sketch taken at a point 100 ft. from the front angle of the building is also given.

The proposed drainage is shown on the ground and block plans

Foundations.—Strip off vegetable soil, excavate wall trenches to required depths, and re-spread surplus at back of site.

Base of walls to be carried down below the frost line; excavation of trenches to be 2 ft. deep. Lay in trenches Portland cement footings 18 in. wide by 7 ft. deep. The spread of foundations being twice the thickness of the (9-in.) wall, and depth 1½ times the projection of foundations beyond wall on either side.

Fill in over site between walls with layer of hard clinkers or broken stone closely packed and consolidated; lay over the whole good gravel concrete, 6 to 1, to be done in one day to prevent cracks or faulty adhesion.

External Walls.—External walls to be built of hollow concrete blocks, 9 in. thick by 9 in. high by (about) 18 in. long, and set in mortar. All blocks to be machine-made, and well damped before setting so as not to absorb water from the mortar. Mortar to be used depends on the district, but here 1 part of cement, 4 of slaked lime, and 3 of sand will no doubt be suitable. The blocks being cast in moulds, any suitable length can be turned out, the outfits proposed and on which the cost is based making them up to 18 in. in length. Blocks to have a "rock-faced" external surface. Buttresses, heads, sills and angle jambs to be formed in solid concrete and the heads and angle jambs to be reinforced. The aggregate for concrete blocks, etc., to be cement, sand, and shingle and stone screenings. It is not proposed to colour the facing blocks by mineral oxides or otherwise. The front porch side walls to be 5-in. thick solid blocks, properly bonded.

Internal Divisions.—Internal divisions to be 2½-in. thick partition slabs, 18 in. by 12 in. or 27 in. by 16 in., made with holes running through the slab, for lightness and cheapness, and with groove and tongue joints, smooth face and set in mortar. Aggregate to be cement, sand, and gravel or breeze, etc.

Chimneys.—Chimneys and flues to be formed in solid blocks and stacks to be (solid) "rock-faced" building bricks. Down-draught is prevented by a concrete slab cover, the smoke openings being at the sides and specially moulded.

Floors.—Floors of principal rooms—viz., living-room, bedrooms, bathroom, and hall passage—to be wood boards. Ash concrete to be laid over the gravel concrete and 1-in. thick grooved and tongued floorboards nailed down to same. To level up the concrete bed and avoid any air spaces, fine ash to be spread over concrete bed as may be required and to level same.

Floors of scullery, larder, w.c., and back lobby to be laid with concrete paving tiles, 7 in. square and coloured by use of coloured sand, granite or other material, and laid and grouted in cement

Roofs.—The roofs to be double hipped and framed together with 7-in. by 2-in. hip rafters, 3-in. by 2⅛-in. common rafters, and 4½-in. by 1½-in. plates and 9-in. by 3-in. purlins. Feet of spars to be wrought. Roofs to be covered with concrete interlocking tiles, with both side and head lock on roof battens or laths fixed to a gauge of 8 in. or 9 in. Hip tiles to be special made. Ceiling joists to be 4 in. by 1½ in. and bond 1 in. thick.

Joinery.—Windows to be 3½-in. by 3-in. wrought rebated frames with 1½-in. thick casements, set in position and built in as the work proceeds; frames to be rebated on jambs to keep out the weather (see Detail).

Doors to be 1½ in. thick, panelled and batten on wood frames, and the internal frames to be grooved for partitions and nailed thereto.

Skirtings to be 5 in.; architraves to doors to be 2-in. single moulds; cupboard fronts to be 1¼ in. thick, single mould and panelled, and divisions and shelving to be 1 in. thick, on proper bearers; window bottoms to be 1 in. thick, nosed.

Ironmongery.—Door and cupboard hinges and furniture to be strong and suitable, and casements to have stays and fasteners (see Estimate of Cost).

Range and Stoves.—Kitchen range to be fixed in living-room and the copper in scullery built at the back of range with flue and damper so that the water in the copper is heated by the range fire, and the idea is to fix a pipe from the copper to discharge into the bath. Register grates and mantels to be fixed in bedrooms, and all to be set with proper bricks, firebricks and fireclay.

Cast Metal Work.—3-in. half-round cast-iron gutters to be fixed to eaves on proper hangers, with all returned angles stop ends, nozzles, and 3-in. diameter cast-iron fall pipe lengths to discharge into rain butts for storage purposes and to avoid drainage therefrom.

Glazier.—All windows to be glazed with 21-oz. sheet glass.

Plasterer.—Ceilings to be lath and plaster two coats; the external walls and the partition slabs, *if necessary*, to be lightly skimmed with lime putty and plaster.

Painter.—All woodwork to be primed and painted three coats approved oils and the iron-work scraped and painted two coats (one coat before fixing).

PAIR OF LABOURER'S COTTAGES.

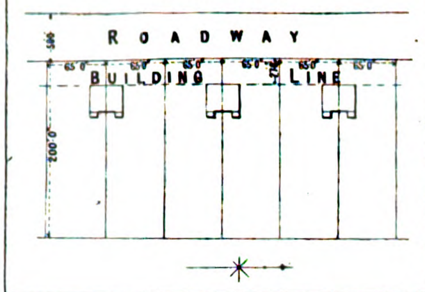
THE CONCRETE AND CONSTRUCTIONAL ENGINEERING COMPETITION 1914.

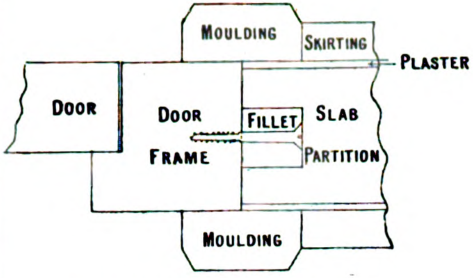
TABULATED PARTICULARS

	ROOMS	DIMENSIONS	HEIGHT	SUPERFICIAL AREA	CUBICAL CONTENTS
H	LOBBIES	4'0" × 3'6" 4'6" × 3'6"	8'0"	29.9	238
K	WORKING KITCHENS	13'0" × 8'6"	8'0"	110.6	884
P	LIVING ROOM	16'0" × 13'0"	8'0"	208.0	1664
B	BEDROOM	14'6" × 12'6"	7'6"	179.0	1342
"	Dº	12'0" × 8'0"	7'6"	96.0	720
"	Dº	8'6" × 8'0"	7'6"	68.0	510

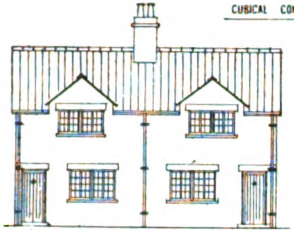
CUBICAL CONTENTS 10,788 FEET

BLOCK PLAN

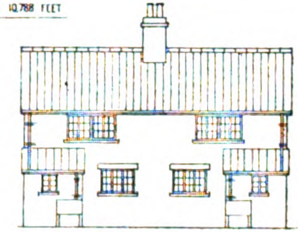




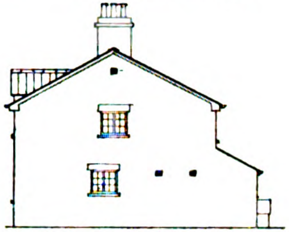
INNER DOOR FRAME. FULL SIZE



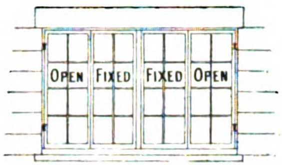
FRONT ELEVATION



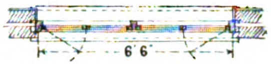
BACK ELEVATION



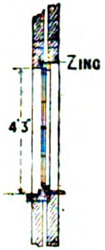
END ELEVATION



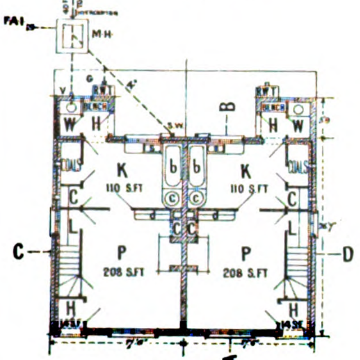
ELEVATION



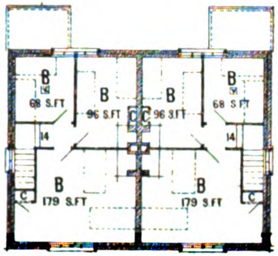
PLAN OF WINDOW



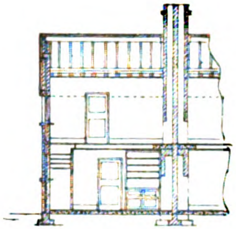
WINDOW SECTION



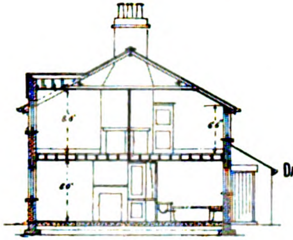
GROUND PLAN



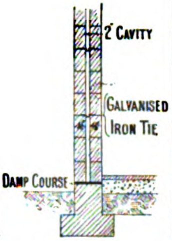
CHAMBER PLAN



SECTION C.D



SECTION A.B



DETAIL SECTION OF WALL

DESIGN NO. 162 ... BY WILLIAM ALLEN KEATES, ARCHITECT.

Method of Execution.

Concrete Blocks.—Concrete blocks to be manufactured by stationary machine of the *side-face* type, as on account of the face-plate being patterned with a rock face it would not be economical to use a *face-down* type. Moulds to be of metal. Machines to be worked and the tamping to be done by hand, and the whole operation of releasing the finished blocks by removing the sides and ends of the mould and withdrawing the cores is done by moving one lever and a reverse action of the lever closes the mould box and replaces the core ready for refilling. The cores form the hollows of the blocks.

The rock-face finish is done by use of a face-plate made by casting the impression taken from a similarly worked block of stone. Internally the blocks to be finished as smooth as possible, to avoid more than the lightest plaster skimming.

In making the blocks care should be taken that the concrete is wet enough to hold together in the hand when squeezed, and after the first 24 hours, if the weather is not too dry, the blocks should be wetted with a hose morning and evening for, say, a week, and on no account should the surface be allowed to dry during this period.

Machines are adapted to make all required sizes of blocks, angle and jamb blocks, etc., by insertion of different moulds. Solid blocks are similarly manufactured.

Partition Slabs.—Partition slabs to be cast in moulds as above described of coke breeze and clinkers, which material is to be well wetted before use by playing a hose on to same to remove any ash, slake any lime and wash out deleterious matter.

Roofing Tiles.—Materials used for making roofing tiles to be 3 parts clean sharp sand or washed granite or stone dust to 1 part of cement. Tiles to be made on hand machines (on which a man can turn out 200 per day), and a colour mixture is applied by means of a colour sprayer; and the mixture consists of 10 parts by weight of cement to 1 part cement colour, a dry powder to required shade.

Floor Tiles.—Concrete paving tiles to be made in simple moulds, 7 in. square, and composed of hard stone, crushed granite or whinstone, mixture 2 to 1; and the tiles may be coloured by coloured sand, granite, etc., and rubbed and polished after laying.

Fixing.—Grounds, etc., and joinery to be fixed by nailing into joints.

Manufacturers.—All concrete blocks, slabs, tiles, etc., can be obtained from various concrete article manufacturers.

List of Fittings and Nett Prime Costs.

	£	s.	d.
No. 1. Kitchen Range, Oven and Sham, 48 in by 51 in., with door, cast bars and fall, cast crow, bracket shelf, cover plate, 13-in. fire, and all fittings complete (as Estimate), p.c. £3 3s.	3	3	0
No. 1. 10-in. Wrought-iron Back Boiler and Unions (as Estimate), p.c. 9s. 6d. ...	0	9	6
No. 1. Kitchen Mantel, and 8-in Jambs to suit (as Estimate), p.c. 17s. 2d. ...	0	17	2
No. 3. 30-in. Mantel Registers (as Estimate), p.c. 10s.	1	10	0
Total	£5	19	8

Note.—The cost of the Kitchen Dresser is included in the "'Joiner's" Estimate, likewise the cost of Cupboards, Shelving and Ironmongery.

With Design No. 162 (By W. A. Keates, 5 Little George Street, Westminster, S.W.).

THESE cottages are designed to meet the requirements of rural working men; after many years' experience in designing cottages on various estates about the country. As a rule, the rooms in cottages are too small, and the parlour generally provided, in my opinion, is almost useless, except as a bedroom. In the design submitted a large living-room is provided, approached by a lobby entrance, and is fitted with cupboard and dresser, and larder under stairs; working kitchen in rear, fitted with copper and bath, the former supplying bath with hot water, the bath to have hinged cover, and there is a sanitary ware sink with cold water laid on. Cupboard for pots and pans and coal place, back lobby and w.c. The rain-water from back part of the cottage to be collected into an iron tank with tap. Over and partially in the roof there is a large bedroom in front and two smaller in rear—two with fireplaces. The small room to have 6-in. by 6-in. ventilator in ceiling and over door. As requested, the rooms have two beds in each in different positions. Concrete is intended to be used as far as practicable.

Specification.

Excavator and Bricklayer.—Dig over the site to be built upon and remove all vegetable matter, and dig trenches for the foundations and footings. The earth removed to be used for making up site to floor line and any surplus distribute over the land at back of cottages.

Lay the drains as shown with 4-in. glazed stoneware socketted pipes, concrete manhole and iron cover, fresh-air inlet, 3-in. vent pipe, two gulleys and traps and a 4-in. interceptor to each cottage.

The aggregate for the concrete to be good local gravel, crushed stone or brick, graded to pass through a sieve of ½-in. mesh, and coarse pit or river sand.

The best Portland cement to be used, and samples will be selected from the bulk for tests. The proportion to be 5 to 1, that is 3 of sand and 2 of aggregate to 1 of cement by cubic measurement, mixed upon a proper board, turned three times dry, watered in due proportion, and turned over at least three times in the wet state. The water to be applied with a fine spray. The blocks to be 32 in. by 9 in by 4½ in., and moulded in a Winget (U.K.) machine. The slabs for the partitions to be 2¼ in. thick.

The outer walls to be "hollow," having two 4½-in blocks and 2-in. cavity tied with galvanised iron ties, built upon ordinary concrete footings, bedded and pointed in mortar. Form the chimney breasts and stack above roof in concrete slabs, and all partitions in 2¼-in. thick slabs.

Cover the ground floor with ordinary concrete 6 in. thick, also all the upper floor hearths.

Heads, sills and lintels over openings to be moulded in concrete, likewise the doorsteps.

Put asphalte damp-course to all walls.

Set kitchen ranges and grates. Supply and fix 15-gall. copper complete.

Carpenter and Joiner.—Form the roofs with plates 4 in. by 3 in., rafters and ceiling joists 4 in. by 2 in., purlins 9 in. by 3 in., and ridge piece 7 in. by 1½ in. Floor joists 7 in. by 2 in., strengthened with bridging. The joists, etc., to be 18 in. from centre to centre.

The upper floors to be laid with 1-in. white deal battens, laid folding, and ¾-in. by 7-in. plain skirting to upper floors.

The outer doors to be 1¾ in., framed and ledged, and the inner doors 1½ in., square panel, hung with cast butts and fitted latches and other suitable fastenings.

The casements (see detail) to have solid wrot and rebated frames and mullions 3½ in. by 2½ in., fitted 1½-in. sashes hung to open outwards, as shown, with cast butts and fitted iron stay bars and fasteners.

The outer doors hung to fir frames 4½ in. by 3 in., and inner doors to frames and fillets to detail. Finished round with 1-in. by 2-in band moulding. Casements to have window boards 6 in. wide.

The staircases to have 1½-in. strings and 1-in. treads and risers, 3-in. by 2-in. shaped handrail and iron brackets.

5-ft. dressers, and hanging cupboards as shown; draining boards to sinks, and copper lids.

Smith.—Put to eaves 4½-in. cast-iron half-round eaves gutters and 3½-in. circular down pipes. Supply and fix 36-in. kitchen range, p.c. 70s., and two sets Leamington bars for bedrooms, p.c. 7s. 6d., to each cottage.

Slater and Plasterer.—Cover the roofs with "Wilhelma" concrete roofing tiles to sawn deal battens 1 in. by 2 in. with 3-in. lap.

Finish with ridging tiles to match.

Render walls and partitions with setting coat of plaster. Lath and plaster ceilings, three coats.

Finish hearths in fine cement.

Lay the floors on ground floor with 6-in. by 6-in. concrete tiles bedded in cement. Run round walls of ground-floor rooms with 1-in. by 6-in. cement skirting.

The roofing and floor tiles to be moulded in a Baumgarten machine.

Plumber.—Perform all flashings to the roofs with 5-lb. milled lead.

Lay on the water from service to a 50-gall. cistern, as directed, and thence to sink in kitchen and w.c., with ½-in. pipe fitted with ball valve and brass draw-off tap over sink.

Fit in closet cane-and-white stoneware pan and trap, also flushing tank with necessary lead piping, and connect up trap to drain.

Supply deal seats upon bearers to closets.

Glazier and Painter.—Glaze the sashes with 16-oz. second quality Newcastle sheet glass, well puttied.

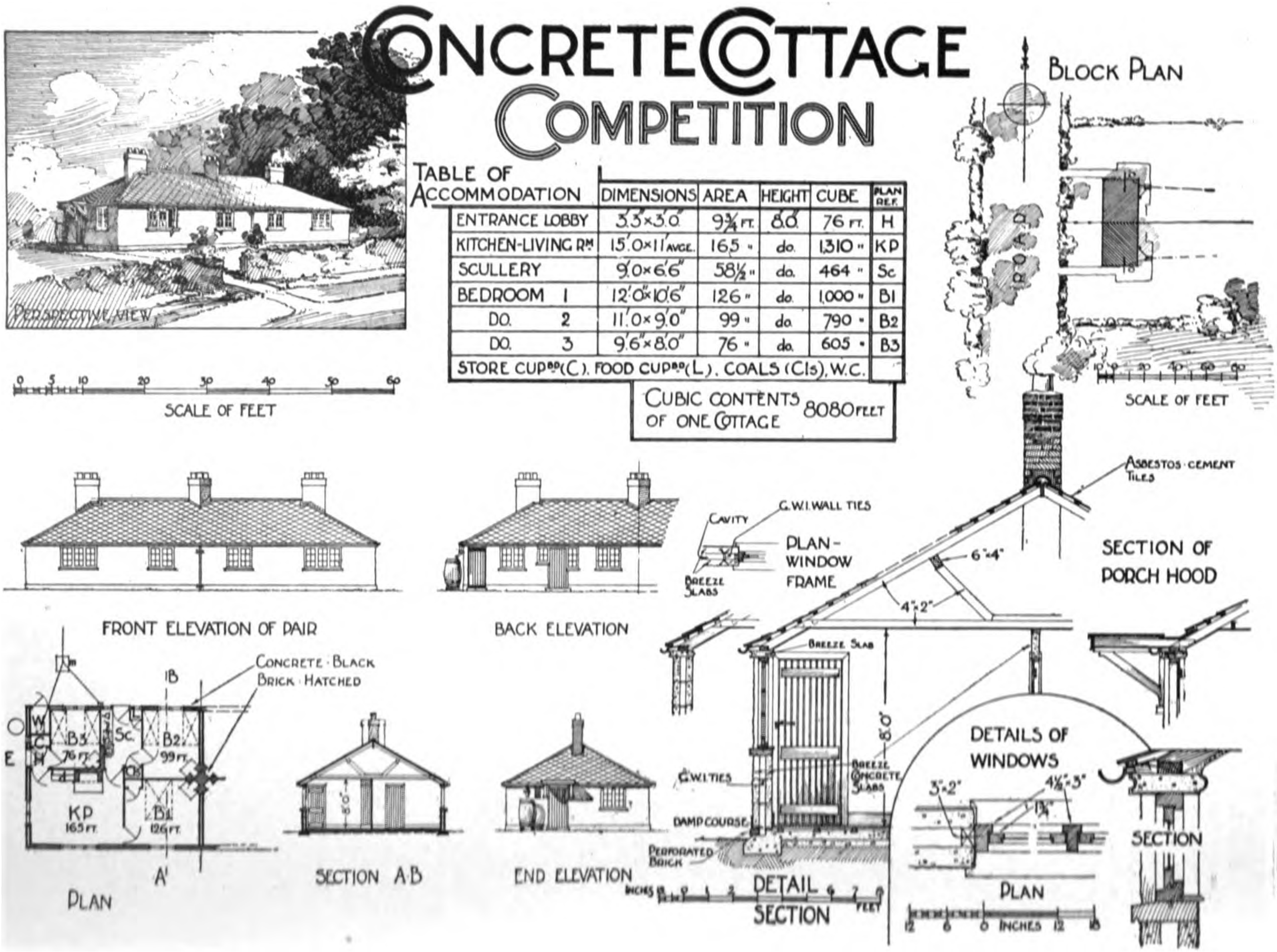
Prime, stop and paint four coats the internal and external wood and iron work.

Estimate of Cost.

To arrive at the cost of the concrete blocks it is assumed that gravel or other suitable aggregate can be delivered on the site at 5s. per load.

	£	s.	d.
5 yds. Aggregate @ 5s.	1	5	0
1 ton Cement	1	17	0
Labour and use machine	0	12	6
200 Blocks, 32 in. × 9 in. × 4½ in. ...	£3	14	6

	s.	d.
9 Blocks or 1 yd., 32 in. × 9 in. × 4½ in. ...	3	3¾
Labour, etc.	0	10
Iron ties	0	3
Mortar bed and pt.	0	2¼
Per yard	4	7



CONCRETE COTTAGE COMPETITION

TABLE OF ACCOMMODATION

	DIMENSIONS	AREA	HEIGHT	CUBE	PLAN REF.
ENTRANCE LOBBY	3'3"×3'0"	9¾ FT.	8'0"	76 FT.	H
KITCHEN-LIVING RM.	15'0"×11' AVGE.	165 "	do.	1,310 "	KP
SCULLERY	9'0"×6'6"	58½ "	do.	464 "	Sc
BEDROOM 1	12'0"×10'6"	126 "	do.	1,000 "	B1
DO. 2	11'0"×9'0"	99 "	do.	790 "	B2
DO. 3	9'6"×8'0"	76 "	do.	605 "	B3
STORE CUPBD.(C). FOOD CUPBD.(L). COALS (Cls). W.C.					

CUBIC CONTENTS OF ONE COTTAGE 8080 FEET

DESIGN NO. 171 ... BY JOHN H. MARKHAM.

The slabs for partitions in proportion.

Prime cost to owner (allowing no profit and deducting trade discounts). Timber and joinery to be supplied by the Cheap Wood Co., of London, or Messrs. Jennings, of Bristol, and fixed locally, *per each cottage.*

	£	s.	d.
Excavator and bricklayer	55	18	1
Carpenter and joiner	37	12	4
Smith and ironmonger	7	14	10
Slater and plasterer	22	1	2
Plumber, glazier, and painter	6	1	0
	£129	7	5

Other fittings not included above—hanging cupboards and shelves, deal dresser, cistern cover, draining board, bath and cover, water supply, ceilings and walls distempered, and drainage—estimated to cost £29.

With Design No. 173 (By John H. Markham, 82, Radnor Road, Harrow).

Specification.

Concrete.—For foundations and under floors to be composed of 1 part of cement or good hydraulic lime to 5 parts of suitable aggregate. Under the floor slab a 4-in. layer of dry core or broken brick to be laid.

Damp-course.—To consist of bitumen sheeting.

Walling and Partitions.—To be formed, as shown, of 3-in. breeze concrete slabs set in cement. The outer wall to be in a double thickness, with a 3-in. cavity, the two shells to be connected by galvanised wrot-iron ties, at least two to each horizontal joint of each slab. The top of the wall to be finished with a slab laid flat, on which will rest the timber roof.

Sills and Steps.—To be of fine-cast concrete or artificial stone.

Roof.—To be constructed of fir timber, as shown, covered with battens.

Flooring.—To be composed of splayed battens tarred and embedded in the concrete in all rooms, except scullery, larder, w.c., entrance to lobby and coals, and to be finished with 1-in. deal flooring in narrow widths.

In scullery, larder, w.c., entrance lobby and coal, the concrete to be finished with a ¾-in. cement floated face.

Roofcovering.—To be of asbestos cement slates of approved manufacture, laid with copper nails and clip, in accordance with makers' directions.

N.B.—In many localities tiles or even slates might be cheaper, and would in that case no doubt be used. (Major's Patent Double Roman interlocking tiles are the most economical roofing known to me; but if they were used the roof should be gabled at each end, not hipped.) The ridges and hips to be formed with half-round or saddleback tiles set and pointed in cement.

Joinery.—To be as shown. Doors to be 1½ in. ledged (with black iron Norfolk latches) hung on strong T hinges to 4½ in. by 3 in. rebated frames externally, and 3 in. by 1 in. linings, with stop nailed on internally and with small flat architrave fillet each side. Windows to be 1¾ in. casements, hung to 4½ in. by 3 in. rebated frames, heads and mullions with 4½ in. by 3 in. oak sunk weathered sill grooved for water bar. The frames to have 3 in. by 2 in. rough fillet nailed on back to fit tightly in cavity of walling.

Plastering.—Externally to consist in the application of thick grout, thrown on either with a brush or trowel, to give a rough coat just sufficiently thick to hide joints in the walling. Internally walls to be finished in one-coat work; ceilings lathed and two-coat work.

List of Fittings and Cost.

	£	s.	d.
Kitchen range	3	0	0
Sink and bath combined in one fitment, either reversible or the bath being arranged under the sink, to be turned on a swivel waste out into the scullery for use	8	0	0
Copper	2	10	0
Bedroom fires, to consist of a very simple iron grate built into the brickwork, and to have a small wood architrave around to stop plaster and a small shelf, if desired ... each	0	15	0
W.C.	2	10	0

Basis of Estimate of Cost.

On the basis of rough quantities, I calculate that the pair of cottages could be carried out at the price of £125 per cottage.

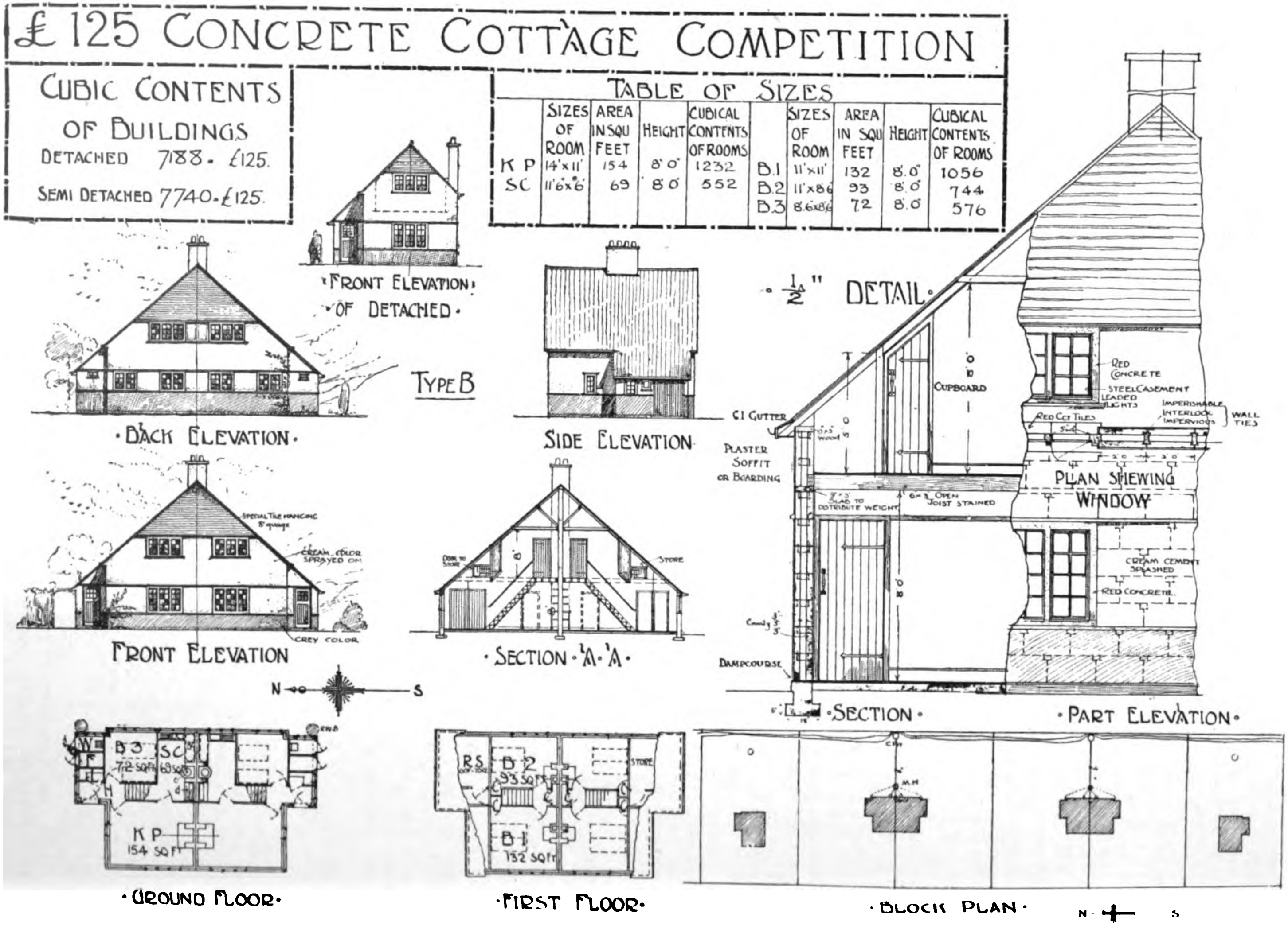


TABLE OF SIZES

	SIZES OF ROOM	AREA IN SQU FEET	HEIGHT	CUBICAL CONTENTS OF ROOMS		SIZES OF ROOM	AREA IN SQU FEET	HEIGHT	CUBICAL CONTENTS OF ROOMS
K P	14'×11'	154	8' 0"	1232	B.1	11'×11'	132	8' 0"	1056
SC	11'6"×6'	69	8' 0"	552	B.2	11'×8'6"	93	8' 0"	744
					B.3	8'6"×8'6"	72	8' 0"	576

DESIGN No. 229. ... BY GEORGE E. CLARK, M.S.A.

The cost in different localities would no doubt vary, but a few of the basis prices allowed were as under :—

The P.C. prices of fittings are given in the Specification.

Concrete partition	2s. per yd. sup.
Concrete in foundations	12s. per yd. cube.
Brickwork	£15 per rod.
Flooring (1-in. boarding)	22s. per square.
Roof tiling and battens	33s. per square.
Windows, including glass and painting	1s. 6d. per ft. sup.
Doors	1s. per ft. sup.
Fir in roof	2s. 6d. per ft. cube.

The price per cubic foot will be seen to work out at about 4d.

With Design No. 229 (By G. E. Clare, M.S.A., Atlas Chambers, 2, Berridge St., Leicester).

Description and Remarks.—The salient points of the two designs submitted are as follows :—

Adaptability of Plans.—To either detached or semi-detached cottages.

Compactness of Plan.—To ensure economy in initial cost and saving in domestic labour.

Convenience and Comfort.—All rooms, staircase, etc., grouped round main entrance lobby and landing. From the entrance lobby in Type A access is obtained to the living room, coals, scullery, w.c., and staircase, no apartment being a passage room.

The Staircase is conveniently placed for conveying furniture, etc., to the bedrooms or approaching them without passing through a room.

The Living Rooms are of ample dimensions; fireplaces being well removed from outside doors, the rooms would be comfortable and free from draughts.

Sculleries are spacious, and fittings conveniently placed; copper, sink, and bath space are shown. A glass door or borrowed light is provided to give supervision of living-room fireplace when working in scullery. In Type A, scullery is entered from lobby, to avoid steam entering living room on washing days.

W.C.'s and Fuel Houses are of ample size, and in Type A are approached from entrance lobby to avoid exposure in winter. The w.c. is also convenient for access from bedrooms.

Larders are of good size, well lighted and ventilated.

Bedrooms are spacious, well lighted, and conveniently planned for furniture and beds. All bedrooms have sunny aspects.

The designs are two examples of cottages in patent standardised concrete slab construction, with damp-proof outside walls 9 in. thick with 3 in. air cavity.

The objects of the special construction are as follows :—

Simplicity and Economy in construction : the walls and window frames can be made and erected by intelligent unskilled labour, thus effecting a great saving in initial cost.

The Construction can be carried out without the use of scaffolding, trestles being used up to first floor line, and above that the joists would be utilised.

Concrete would be used for walls, partitions, roof tiles, window frames, sinks, mantels, etc., and made on the site from very inexpensive raw material for the aggregate, by means of a simple and cheap moulding machine, thus effecting a great saving in carriage.

Structures being Standardised, and formed with much larger units than ordinary building construction, they can be erected much quicker and cheaper—*e.g.,* walls have only eight slabs and four ties to the super yard, as against 100 bricks, or less than one-tenth the number to handle and fix.

A two-light window has only five pieces of concrete, which are simply placed in position as erected.

Concrete Roof Tiles number only 100 to the square, as against 600 plain tiles.

Footings and Foundations are reduced to a minimum, owing to the weights of the walling being only about one-third that of an ordinary solid brick wall.

Buildings are Perfectly Dry and ready for occupation when complete, as slabs are dry when built up.

The Cost of Upkeep is reduced to a minimum, as there are only the eaves, gutter, and down pipe to paint.

Lintols, Woodblocks, and Grounds eliminated, and cost saved, as slabs being made of breeze concrete can be used for nailing to.

Specification.

Foundations.—Concrete formed of 1 of cement to 7 of gravel, burnt ballast, broken brick, crushed clinker, according to local supply, and 1 of sand; 1 ft. 6 in. wide and 6 in. deep.

Footings.—11 in. by 9 in. solid concrete, as before, but mixed 6 to 1, filled in between 11-in. planks.

Dampcourse.—Cement and clean sand, 1 to 3, mixed with 5 per cent. damp-proof powder.

External Walls.—Formed in patent construction of 3-in. slabs with 3-in. air cavity, of standard size 2 ft. by 1 ft. 1½ in. (four to the yard), cast on site or sent from depot; formed of fine crushed and washed engine ashes or slag and Portland cement, 6 to 1.

Patent dovetailed interlocking ties, as shown, formed of washed sand and cement, 4 to 1, and mixed with "Pudlo" to render impervious to moisture.

The walls are built up dry, with a thin joint of cement and sand, and tied together with the interlocking imperishable ties. Plinth formed of 3½-in. slabs. The outside is finished with plinth coated in cement and sand natural colour, and, above plinth, cement and sand and Glidden cement stain, mixed to a cream colour and blown on with an air sprayer to give a rough-cast effect. This gives a permanent artistic damp-proof finish.

Partitions.—Formed of single 3-in. slabs on surface concrete.

Roofs.—Covered with red concrete tiles, "Double Roman" pattern, on 1½ in. by ¾ in. laths.

Plastering.—Walls, partitions, and reveals treated with setting coat only gauged with Sirapite. Red cement fillet around floors. Walls coloured with washable distemper.

Ground Floor.—Solid concrete, as described for walls, and "Pudlo." Living room and lobby finished with a thin coating of Ebnerite red plastic cement; others, cement rendered red colour.

First Floor.—6-in. by 3-in. joists, spaced as shown, treated with Solignum, ⅞-in. tongued boarding distempered white on the underside between joist. Ceiling of first floor, "Beaver Board" and distemper.

Windows.—Made of cement and fine granite by the Croft Granite Co., finished red colour, grooved into wall cavity. Each head, sill, and mullion in one piece, weather tile at base and cement weathering at head. Opening lights to have special L iron sashes made on new economical system, hinged to a pin let into sill, with stay and fastener; glass to be 16 oz. in lead cames, wedged and cemented into grooved rebates; inside ledges formed with 12-in. by 6-in. red concrete tiles.

Sink and Mantelpieces.—Made in special granite concrete to designs, and finished with cement enamel.

Doors.—⅞ in. ledged and braced; special strap hinges and Suffolk latch; 3-in. by 2-in. frames; plain architraves, etc.

Stairs.—9-ft. by 1-ft. treads, ¾-in. risers, 1¼-in. strings.

Fireplaces.—As fittings list.

Painting.—Outside, grey graphitum paint to ironwork; woodwork, brown Solignum inside and out.

List of P.C. Allowances for Fittings.

	£	s.	d.
Living Room, special open fire kitchener, large oven, small fire, 30 in.	1	8	0
Copper rustless pan and furnace	1	5	0
Two bedrooms, fireplaces built up in firebricks and wrought-iron bars fixed in same, complete with all firebricks, p.c. each	0	10	0
Living-room mantel in cement finished with enamel	1	0	0
Two bedrooms, ditto ditto, each	0	10	0
W.C. pan, seat, cistern, etc.	1	5	0
L iron casement, complete with stay and fastener, each	0	7	6
Leaded lights and 16 oz. glass, per foot	0	0	8
Garden City thumb latches with pin fastener complete, per set	0	1	0
Special strap hinges, per pair	0	1	0

Data of Cost.

Comparative cost of brick walling and the patent concrete cavity walling, as shown :—

BRICK CAVITY WALL. Builder's price.	Per yard. s.	d.
9-in. solid wall	5	6
E.O. cavity wall	1	0
Plaster ren. and set	0	8
Roughcast or stucco	1	0
Lintols, plugs, etc.	0	4
Total per yard	8	6

CONCRETE CAVITY WALL. Cost.	Per yard. s.	d.
Two 3-in. slabs	2	6
Four impervious ties...	0	4
Fixing	0	9
One ct. plaster	0	4
Cement outside	0	3
15 per cent. profit	0	7
Total per yard	4	9

Comparative cost of wood windows and wood casements and the patent concrete windows and iron casements (three-light frame taken as example) :—

CONCRETE FRAMES.

Croft Granite Co.'s price, 24-ft. head	£	s.	d.
Sill mullion, etc.	0	11	0
Tile sill	0	3	0
Fixings and labour	0	1	6
One iron casement	0	7	6
Twenty leaded light, 8d.	0	11	2
Fixing	0	1	6
	£1	16	8

27 ft. @ 1s. 4d. ft. Saving 33⅓ per cent.

WOOD FRAMES.

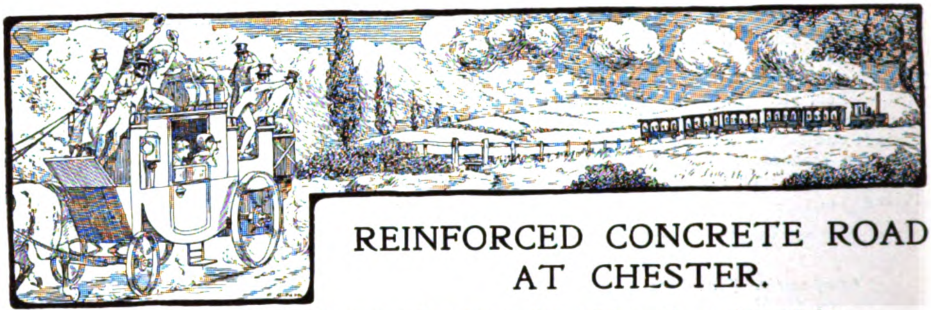
	£	s.	d.
27-ft. frame, 1s. ft.	1	7	0
Sashes, 8d. ft.	0	13	4
Glass, 4d. ft.	0	6	0
Painting, 1s. 7d.	0	6	0
Lintol	0	2	6
	£2	14	10

27 ft. @ 2s. ft.

Comparative Quantities.

	£	s.	d.	Saving. £	s.	d.
90 yds. brick walling @ 8s. 6d.	38	5	0			
Ditto concrete ditto @ 4s. 9d.	21	7	6	16	14	6
70 yds. partitions, brick and plaster, @ 4s. 6d.	15	15	0			
Ditto concrete @ 2s. 6d.	8	15	0	7	0	0
Roof tiles.						
5 square slating @ 30s.	7	10	0			
Ditto concrete tiles @ 20s.	5	0	0	2	10	0
Windows, saving 6s. per light for 16 lights				4	16	0
Total saving per cottage				£31	0	6

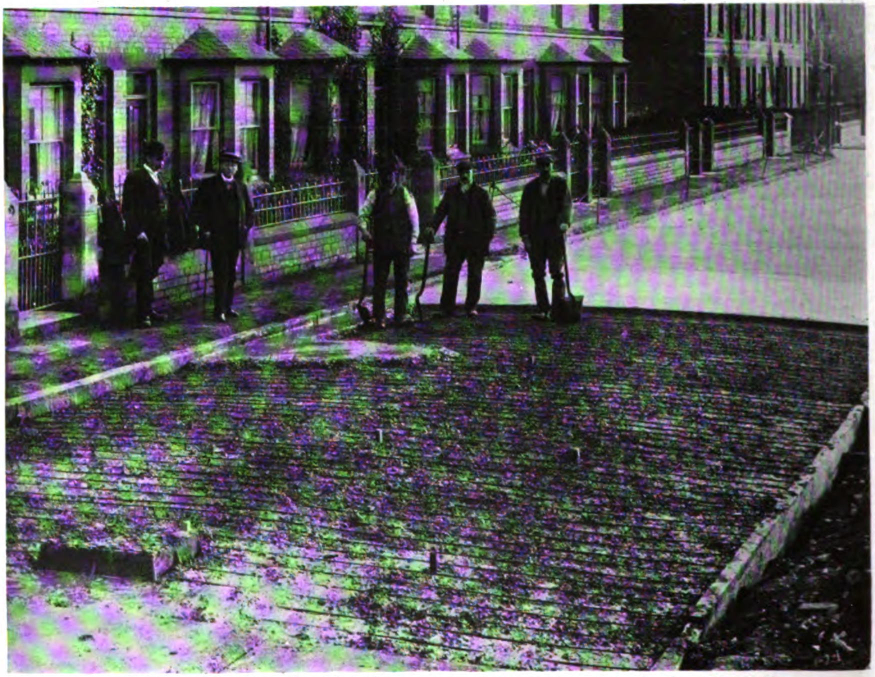
This represents 1d. per foot on the cubical contents of the cottage, calculated at 7,500 ft. Therefore, if an ordinary brick cottage costs 5d. per ft. cube, the same cottage can be done in concrete for 4d., which is the basis for calculating the cost.



REINFORCED CONCRETE ROAD AT CHESTER.

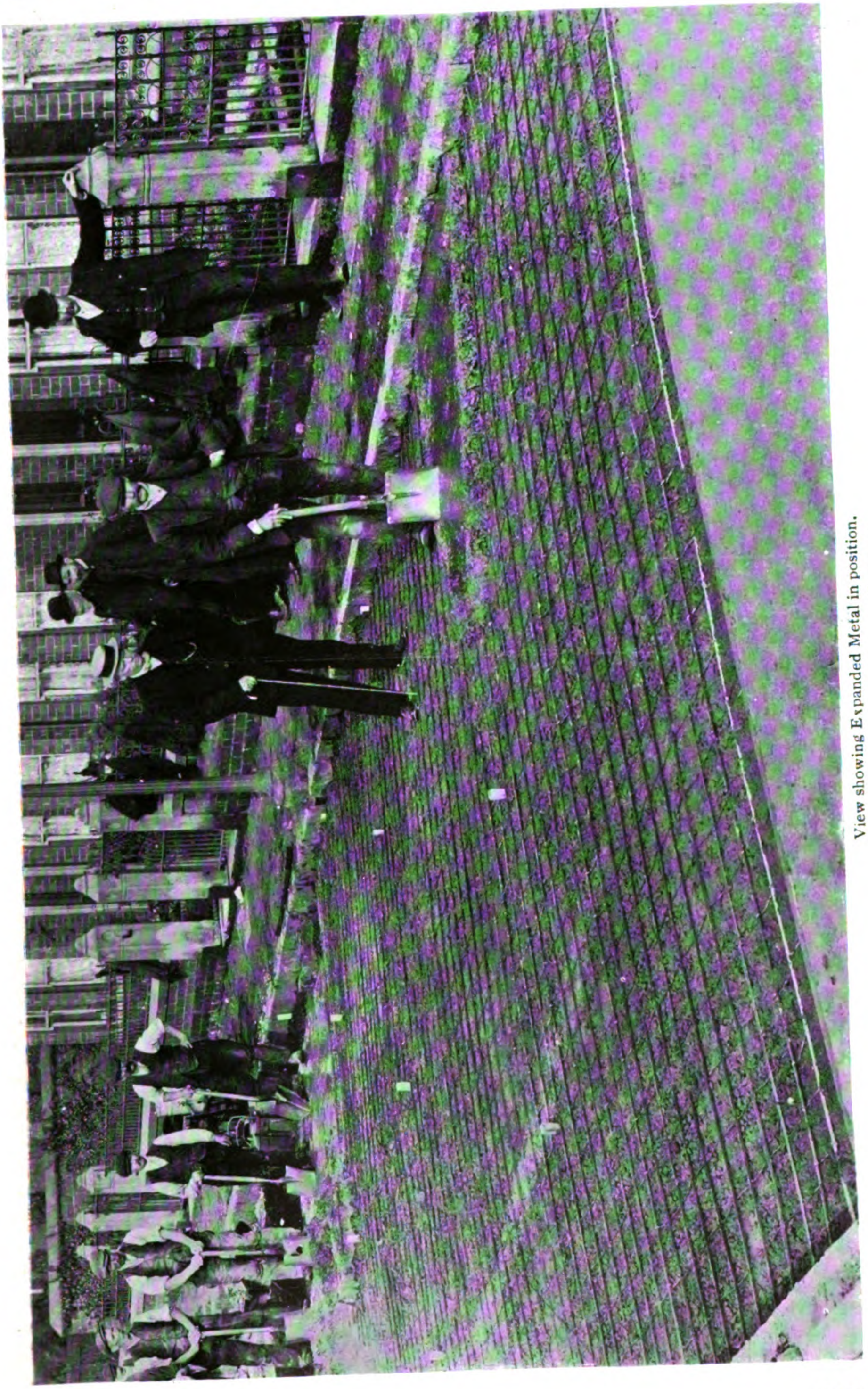
We have published in this journal, from time to time, articles on the use of concrete for road construction, mainly as applied to the United States, and these articles have shown that the material has been successfully applied for road construction over there. So far, however, little progress has been made in this country in the use of concrete for our road surfaces, although it has been used for foundation work and the like. Doubtless, therefore, the following article which has reached us on a reinforced concrete road at Chester will prove of considerable interest to surveyors and others interested in the subject of good roads.—ED.

ONE of the first reinforced concrete roads in this country is that depicted in the accompanying photographs to this article. It is known as Robert's Lane, Saltney, on the outskirts of Chester, is 950 ft. long, 20 ft. broad, and was laid about two years since by Mr. W. Matthews Jones, the borough surveyor of Chester, in the following manner.



View of Road showing Metal Reinforcement and the Placing of the Surface Concrete.
REINFORCED CONCRETE ROAD, CHESTER.

Having a clay sub-soil to deal with, he placed upon that 2 in. of cinders to bind it, then on this $2\frac{1}{2}$ to $3\frac{1}{2}$ in. of concrete. The latter was made of five parts of broken granite—$\frac{3}{4}$ in. to small 2 in. (mixed)—and sharp sand to one of cement, "J.B.W." brand. On the top of this a reinforcement of the Expanded Metal Co.'s rib expanded steel No. 8, which is 8 in. square, was



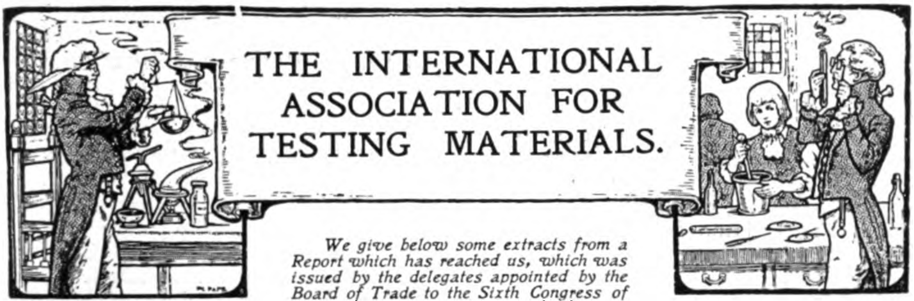
View showing Expanded Metal in position.
REINFORCED CONCRETE ROAD, CHESTER.

employed. It was placed across the road in lengths of 20 ft. by 5 ft. 4 in. Then covering the reinforcement, concrete of the same character as described was put down to a depth of 3½ to 4½ in., and the surface roughly smoothed over. The greater depth of concrete—8 in.—was 12 in. from each kerb-line of the road, where heavy loads might be standing; other than this, it was all 6 in. of concrete. When finished the road was closed for three weeks to enable the concrete to set properly, and during the early days of this period was kept well watered.

The traffic on this road has been estimated at about 60 tons per day, but it is a slowly increasing traffic, which will be more marked as house property in the neighbourhood is developed. For a year Robert's Lane, with the traffic mentioned running over it, remained without anything further being done; then the road was tar sprayed and sprinkled with granite chippings. Another year passed and the surface was treated in the same manner. The cost of the road, including excavation, concrete and expanded metal, was 3s. 10d. per super yard, and the tar spraying and fine granite chippings put on the surface cost from 1d. to 1½d. per super yard. Mr. Matthews Jones considers that at least a fortnight should elapse after the completion of a road before it is open for traffic, and that for part of this time it should be kept well watered.

Finished Road (dark patches due to wet—road had just been watered).
REINFORCED CONCRETE ROAD, CHESTER.

A sewer was laid in Robert's Lane before the concreting was done, as were also gas pipes, electric cables and water-mains. No special provision was made for getting at the sewers, etc., needing repairs, but in future, before commencing any work of this kind where pipes are already under the road, notice will be given to those concerned to have their mains and surfaces examined so that, if found faulty, they may be put in perfect order. In the case of new roads provision will be made for all such pipes to be laid in the footpaths, and under town-planning schemes spaces can be left in the footpaths for such pipes.



THE INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

We give below some extracts from a Report which has reached us, which was issued by the delegates appointed by the Board of Trade to the Sixth Congress of ***the International Association for Testing Materials held in New York.—ED.***

In view of the announcement that the next International Congress of the Association for Testing Materials is to be held in St. Petersburg next year—August 12th to 17th—it may not be inopportune at this moment to make some reference to the Report issued by the Delegates appointed by the Board of Trade to attend the Sixth Congress of the Association in New York in 1912. This report has only just reached us, and it is interesting on account of the fact that this was the first occasion on which the British Government has taken official note of the Association by appointing delegates to a Congress, and some of the recommendations discussed had, in the opinion of the delegates, a serious bearing on the trade interests of this country.

The delegates who attended the Congress on behalf of the Government were Professor Wm. Cawthorne Unwin, Messrs. A. Denny and Bertram Blount, and the Report is also signed by Mr. Leslie S. Robertson as representing the British Engineering Standards Committee.

Before giving some extracts from the Report, we would add that the Government have just made a grant of £40 towards the work of the Association.

After some preliminary notes dealing with the formation of the Association and the congresses held since the date of the foundation in 1884, the Report, in dealing with the objects of the Association, says:—

> *Objects of the Association.*—The objects of the Association were originally purely scientific, the discussion of methods of testing and the determination of the qualities of materials of most service for industrial use, but these questions touch closely on trade and commercial considerations which, in the opinion of the Delegates, call for the close attention of British representatives. The work of the Association is subdivided into sections dealing (A) with metals; (B) with natural and artificial building stones, cements, mortars and road materials; (C) with other materials such as timber, rubber, paper, &c. Proceedings are published in German, French and English, and these constitute a very valuable storehouse of information. The papers presented at the New York Congress, as printed, form a volume of about 800 pages. Much of the research work put before the Congress is the work of individual members. But a number of Committees are appointed to study special subjects and these Committees formulate the results of their investigations in recommendations which are in many cases subsequently adopted by the Congress and carry the authority of the Association.
>
> The decisions or recommendations of the Congresses have no binding force on any group of its members. But the Association, in twenty-eight years of serious work, has attained a position of such authority and influence that its

> recommendations carry great weight and cannot be disregarded by those interested in industries concerned.
>
> At the New York Congress, in addition to the three representatives of the Board of Trade, the British Engineering Standards Committee was represented by Mr. Leslie S. Robertson; the National Physical Laboratory by Dr. Rosenhain; the Institution of Civil Engineers by Dr. Unwin and Mr. Alfred Noble; the Iron and Steel Institute by Mr. G. C. Lloyd (Member of Council of the Association); the Institute of Mining and Metallurgy by Mr. F. W. Harbord, and the Steel Ingot Makers' Association by Mr. Saniter of Sheffield. There is no doubt that a much more prominent part in the proceedings was taken by the British representatives at this than at any previous Congress. It is believed that on all points which appeared important to the British representatives the decisions arrived at were satisfactory to them.

The Report deals at some length on the subject of International Specifications, one of the subjects taken up by the Association, and the delegates state :--

> *International Specifications.*—There is general consent that, provided it is possible to agree on the adoption of international specifications for iron, steel, and cement, certain advantages would result. It would be an extension to a much wider field of the principle which has proved beneficial in the publication of national specifications in England, the United States and Germany. Hence it is not surprising that as early as 1897 the International Association formed a Committee "To find ways and means for the introduction, on the basis of existing specifications, of uniform international specifications for testing and delivery of iron and steel materials of all kinds." The difficulties, however, soon came to be realised. In 1896, a German Association for testing materials was formed, and undertook the task of formulating national specifications, and in 1901, the British Engineering Standards Committee, and in 1902, the American Society for Testing Materials addressed themselves to the same task.
>
> Up to about six years ago, no progress had been made by the Committee of the International Association appointed to draft international specifications, except the collection of information. In 1906, Dr. von Rieppel (of Nuremberg), its very able Chairman, proposed to facilitate the work of the Committee by limiting its scope. It was then resolved by the Association at Brussels that the work of the Committee should be restricted to an attempt to find common specifications by compromises of the clauses of the British, German and American specifications. A special sub-committee was also formed to deal with cast iron. After much correspondence, extending over several years, the members of the Committees found it to be impracticable to arrive by consent at any result.

After reporting on some of the difficulties that presented themselves in attempting this work, it is stated that :—

> It appeared to the British Delegates that the Association is not a body sufficiently representative of engineers and manufacturers to be entrusted with the drafting of international specifications, for although many manufacturers are members, they do not take an active part in the Congresses. There is the further difficulty that it would be an extremely cumbrous body through which to make such modifications in specifications as would be desirable from time to time. Considering steel only, the ores and the processes of production differ in different countries. Specifications could easily be so drawn as to favour one country at the expense of others. It is not at present clear that any country has arrived at a specification securing absolutely the best quality consistent with considerations of cost, even for its own production. The tendency of any attempt at compromise of the requirements of different countries would be to arrive at a specification of quality less satisfactory than that of any one country, whereas, if possible, an international specification should, in the interest of consumers, be of the highest standard.

The question of international specifications has been referred to at length as one of much importance, one on which recommendations adopted by the Association, though binding on no country, might have serious influence on industry. If international specifications are possible at all, they can only be drafted safely after much longer discussion, by agreements reached step by step, and with the sanction of bodies larger and more representative than Committees of the International Association.

The Report then refers to Portland cement, and reads as follows:—

Portland Cement.—Section B. is concerned with non-metallic structural materials. Of such substances, that which needs special care in the prescription of methods of testing is cement, and on this account the principal work of the section relates to this subject.

Methods of testing cement are well established and understood in all countries, but their unification is not complete, and the International Association for Testing Materials has been endeavouring to achieve this unification. There may be, and are, differences of view among the representatives of the various countries, and these are best composed by personal discussion.

That method was used in the present instance. There was a sharp difference of opinion between the British and other delegates, and it was therefore particularly necessary that an exposition of the British case should be made in such a way as to carry conviction, and avoid its being lost by the weight of mere numbers.

The chief matter of contention arose in this way: At the Congress in Copenhagen in 1909, the Report of Committee No. 32 appointed to deal with the question of accelerated tests for the constancy of volume of cement was presented. This Report was the outcome of work dating from 1903, in which all countries concerned had been asked to participate. As the result of numerous experiments it was decided to recommend the adoption of the Le Chatelier test, which had already proved its value by many years of use in France, and, more recently, in England. It has been adopted in the British Standard specification. The members of the Committee who attended at Copenhagen were unanimous in their recommendation. When their recommendation was submitted to Section B., opposition was offered by Germany and America. After discussion, Section B. passed a resolution accepting the recommendation of Committee No. 32 by a substantial majority, and this was confirmed by the Congress in full session in Copenhagen. The terms of the resolution thus finally passed are as follows:—

> "The Congress decides to recommend the method of Le Chatelier as
> "the standard accelerated test for the constancy of volume of cement."*

Since that date continued and determined attacks have been made on this method of testing by the German Association of Portland Cement Makers, which culminated in the presentation at New York of two resolutions demanding the rescission of the Copenhagen resolution. Experimental evidence obtained since the date of the meeting was adduced to show that the test was liable to give discordant results, and might condemn cement which had given satisfactory results in practice. At the same time it was demonstrated that the great majority of German cements passed the test with ease.

Reverting to the contentions of the German representatives who brought forward resolutions for the rescission of the Copenhagen decision, it was pointed out that they fall under two heads: (1) that the test gives discordant results, and (2) that it may condemn cement which gives good results in practice. Without going into technical details, these objections may be very simply met. Discordant results are chiefly due to experimental errors made by careless or unskilful operators, but also arise from the fact that cement if stored, even in closed vessels, changes in quality, and thus may give different results when tested at different places and at different times. As to the condemnation of cement which may give satisfactory results in practice, it is only necessary to say that no cement which passes the Le Chatelier test has been known to give other than good results in practice, whereas cement which would fail to pass the Le Chatelier test has often given disastrous results in practice; evidently a buyer has a right to employ so valuable a safeguard.

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* Adopted with the reservation of Congressists from Germany.

The constancy of volume of cement, or, in other words, that chemical stability which prevents the occurrence of harmful internal stresses, is of such importance for all structures that no test which does not ensure that the cement passing it shall be unexceptionable in this respect, can be regarded as effective, or accepted internationally.

This obvious conclusion had its influence at the Congress. The upshot of the private and public discussions which took place was that the German and American representatives agreed to their motion being withdrawn, and the Le Chatelier test stands accepted by the International Association for Testing Materials.

There being on all sides a spirit of conciliation and a desire for mutual understanding, a mode was found whereby those members of the Congress who were in doubt as to the value of the Le Chatelier test could resolve their doubt or devise another and a better test. It was decided to continue the work of Committee No. 32 which, be it said, relates to the study of accelerated methods for the determination of constancy of volume of cement, and is in no way confined to the consideration of any particular test. The resolution embodying this view, runs thus:—

> " That the task of further examining all methods of accelerated tests " for the constancy of volume of Portland cement be referred to a Com- " mittee, and that it shall be an instruction to this Committee to invite " experiments by various testing laboratories, and also to have some experi- " ments made by an official testing authority in each country concerned,"

and was passed unanimously by Section B. and by the Congress in full session.

The second matter of commercial importance discussed in Section B. is the question of permissible limits of sulphuric anhydride in Portland cement. Some countries, *e.g.*, France and the Argentine, require for harbour work not more than 1.2 or 1.5 per cent. of this constituent. English and French makers are able to comply with this requirement easily, but many German and some American manufacturers are not. A resolution by the Association of German Portland Cement Manufacturers was presented thus:—

> " The Congress recommends that a uniform permissible maximum " limit of SO_3, namely, 2·5 per cent., be generally adopted in specifications " for Portland Cement, whatever may be the purpose for which the cement " is intended."

This means that in neutral markets any cement having not more than 2·5 per cent. of sulphuric anhydride would come in with the cachet of the International Association for Testing Materials.

This was strongly opposed, and ultimately the following resolution was substituted:—

> " That the Council be requested to appoint a Committee to report at " the next Congress regarding the effect of SO_3 in Portland Cement."

This was accepted unanimously and it will be seen that no limit has been set by the Association for the percentage of sulphuric anhydride in cement.

The Report then goes on to deal with the subject of nomenclature, and then reference is made to the Congress of 1915 in St. Petersburg, and in regard to the question of future Congresses the Report states:—

Future Congresses.—The idea was discussed whether the subsequent Congress, in 1918, could be held in London. If such a proposal were entertained, then it may be pointed out that some decision must be arrived at during the next three years, so that an invitation could be sent to the Congress in 1915 If Great Britain is to take a share in the proceedings of the

> Association at all proportionate to its industrial interests, it would be quite fitting that steps should be taken to invite the Association to meet in London.
>
> If the Congress met in London it would be essential that some assistance and recognition should be given to it by the Government such as has been accorded in other capital cities. It would also be necessary that some of the technical societies should take a large part in organising the meetings, and providing such entertainments and visits as are features of the Congress.
>
> It is understood that at Copenhagen the Association was recognised by the Government, and the delegates were received by His Majesty the King of Denmark.

The delegates report on their visit to the Bureau of Standards at Washington and on visits to Pittsburg, Buffalo, and Niagara.

In conclusion, the following recommendations are made by the delegates for the consideration of the Board of Trade.

> *Recommendations.*—(1.) That His Majesty's Government recognise the International Association for Testing Materials by continuing to appoint delegates to the periodical Congresses, with instructions as to their duties.
>
> (2.) That a subvention to the funds of the Association should be made either directly or through the Departments interested in the work of the Association.
>
> (3.) That should the Congress meet in London in 1918 His Majesty's Government should accord the Congress official recognition.

REINFORCED CONCRETE ICE-HOUSE AT PASCO, WASHINGTON.

A Structure of 30,000 Tons Capacity, Built of Reinforced Concrete with Regranulated Cork Insulation.

The following particulars regarding the construction of a reinforced concrete Ice-House may be of interest. Our description is taken from the "Railway Age Gazette," U.S.A., from an article by Mr. H. J. Church, to whom we are indebted for our illustrations.—ED.

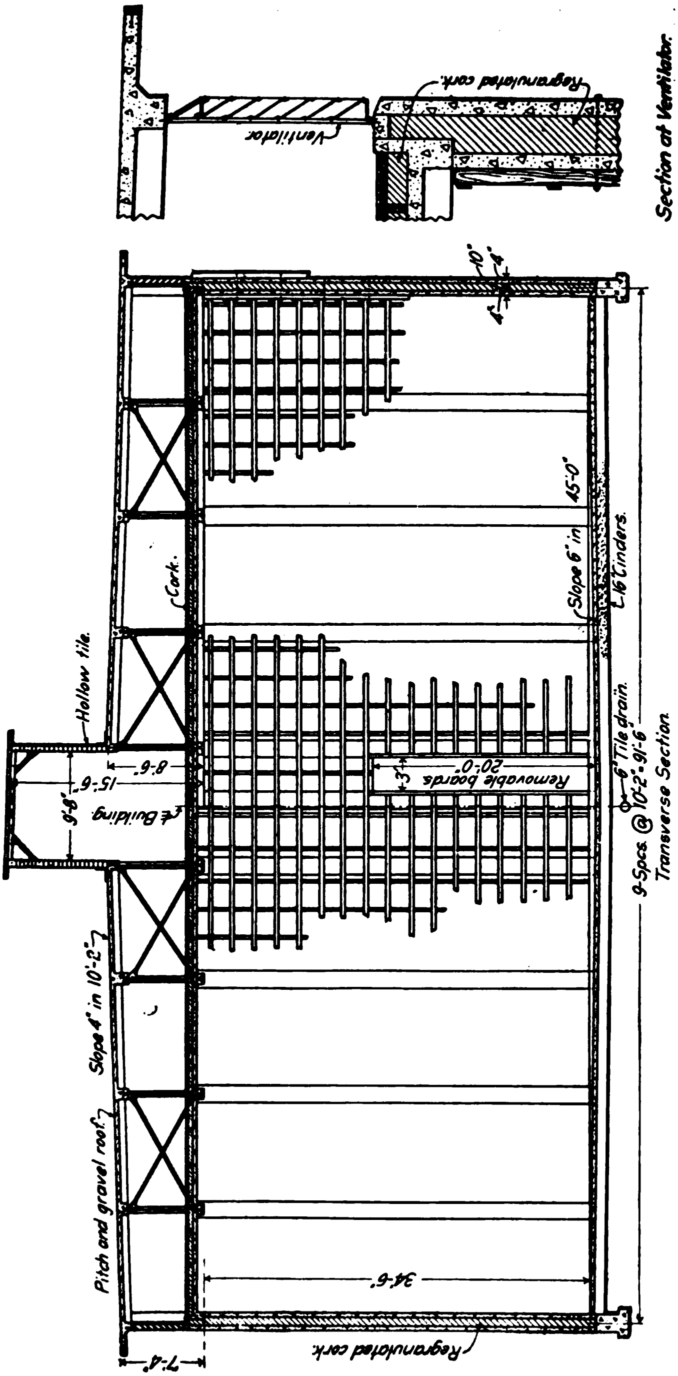
THE refrigerator cars used by the Northern Pacific to transport the fruit raised in the Yakima valley and the Walla Walla district are iced at Pasco, Washington. Two years ago this company suffered severely when almost their entire supply of ice was lost through the burning of a large wooden ice-house at Pasco. When the railroad decided to rebuild, the question of fire-resisting construction was considered, and even though investigation proved that reinforced concrete was about 25 per cent. more expensive than wood, it was decided to construct the new building of this material.

The new ice-house is 483 ft. long, 94 ft. 6 in. wide, and 41 ft. 10 in. high to the roof at the centre line of the side walls, and has a storage capacity of 30,000 tons of ice. It is divided into 12 compartments by walls of the same construction as the exterior walls. These walls consist of two 4-in. concrete walls reinforced vertically and horizontally, and cast with a 10-in. space between them, which is filled with fine regranulated cork for insulation.

The walls are made rigid by building columns spaced from 9 ft. to 13 ft. 4 in., cast monolithic with the walls. Insulation around the exterior columns is provided by building U-shaped concrete pilasters and filling the space formed by the U with granulated cork. These pilasters were cast monolithic with the outside walls. The walls are given additional stiffness between columns and made to act together by inserting two 2-in. by 10-in. fir planks spaced equi-distant and extending the full height of the wall. Bolts, spaced 4 ft. apart and running through both walls on the same vertical line as the 2-in. by 10-in. timbers, hold the two walls solidly together and give considerable additional stiffness to the structure as a whole. These bolts are long enough to hold in place the lagging on the inside of the building, which will be described later.

The floor is made of a 4-in. concrete slab reinforced in both directions, and laid on 16 in. of cinders well tamped for insulation. To provide drainage and give the ice a tendency to tip away from the walls, the floor is sloped from all four sides to the centre in each compartment.

The ceiling is of the beam and slab type of reinforced concrete. The slab is 4 in. thick, reinforced two ways. The beams running lengthwise of the building are framed around the bottom chords of the trusses which



Section at Ventilator.

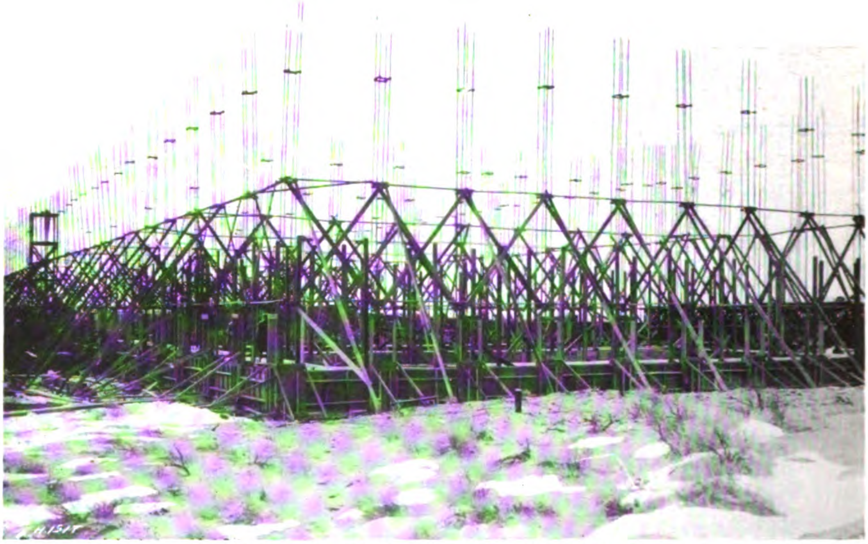
Transverse Section.

Section Through Northern Pacific Ice-House Showing Cork Insulation.

support the roof and ceiling. The beams framing into the longitudinal beams are spaced so as to give panels 13 ft. 4 in. by 10 ft. 2 in. On top of the ceiling slab 2-in. by 6-in. timbers are placed 3 ft. between centres, and fine regranulated cork is tamped between them, giving a 6 in. thickness of insulation. Boards ⅞ in. thick are nailed to 2 in. by 6 in. timbers and covered with two layers of oiled paper. On top of this is placed 1½ in. of cement mortar reinforced with wire netting. This construction gives a solid ceiling and provides excellent insulation.

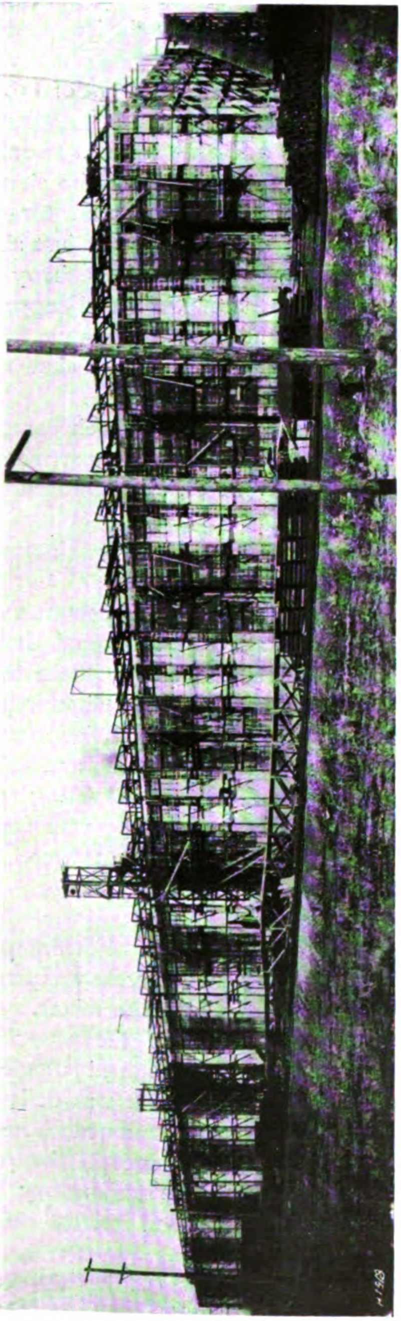
The reinforced concrete roof is supported on 40-ft. steel trusses with sub-verticals supported on the end and transverse walls. The roof slab is divided into panels of the same size as the ceiling and is covered with a tar and gravel roof laid under the Northern Pacific specifications. The slope of the roof is about 4 in. in 10 ft. This double construction of ceiling and roof is designed to give additional insulation and to provide room for ice chutes leading from elevators to the outside of the building. Ventilation of the space between the ceiling and the roof is provided by galvanised iron ventilators fastened to the concrete by means of expansion bolts.

View of Building in Course of Construction.

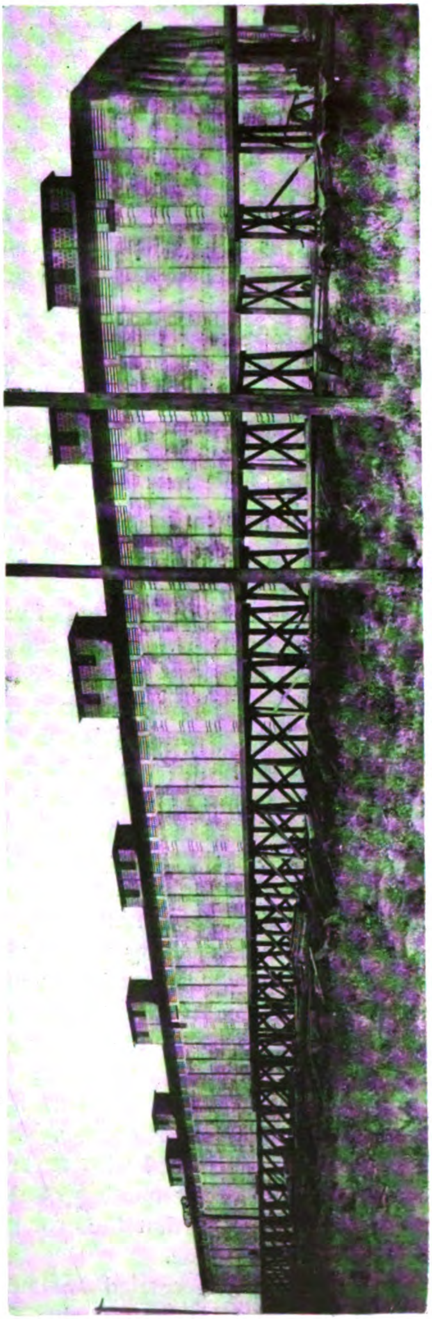


View showing Vertical Reinforcement in Position.
Reinforced Concrete Ice-House, Pasco, Washington.

The cupolas or pent houses built along the centre line of the building are provided for ice chutes and elevator machinery. The frame is of structural



View showing Timbering still in position.



View of Completed Ice-House.

REINFORCED CONCRETE ICE-HOUSE, PASCO, WASHINGTON.

steel supported by two middle rows of trusses and the wall is made of hard burned tile laid in cement mortar except in those parts carrying the slabs supporting the elevator machinery, where they are of hard brick laid in cement mortar. The roof on the cupolas is of reinforced concrete covered with a composition roofing of tar and gravel similar to that on the main roof.

Each compartment is provided with an elevator operated by an electric hoist. These elevators are equipped with all possible safety devices and are driven by 11 h.p. slip ring induction motors, 3-phase, 60 cycles, 220 volts, using external grid resistance in starting, allowing a starting current of 150 per cent. of full load running current. The capacity is 2,000 lb. at a speed of 75 ft. per minute. The cars are constructed of steel and are designed to unload the ice automatically into the chute at the top of the building. The elevator shaft is made of structural steel. It also carries the guides for the elevator cars.

Ice chutes run from each elevator to openings in the side walls just above the ceiling slab, where the ice is delivered to special conveying machinery and transferred to the icing platform. The ice chutes are made of wood supported on wooden bents placed from 10 ft. to 14 ft. apart and have a minimum fall of 1 in 20. The 2-in. by 2-in. oak strips forming the bottom of the chutes are protected from wear by 1-in. by ¼-in. half oval steel strips.

On the west side of the building one door is provided for each compartment for filling purposes, and to give easy access from one compartment to another each division wall has a door 3 ft. wide by 20 ft. high located near the centre line of the building.

All column and beam reinforcement is of medium steel manufacturers' standard specifications.

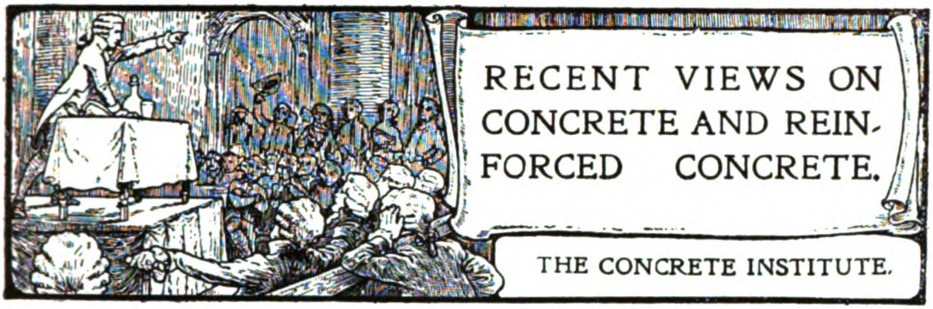
All forms were constructed of wood. Those for the walls and columns were made in sections 4 ft. high, a sufficient number being built to extend the full length of all walls. After the concrete had hardened sufficiently these forms were raised into a new position and used over again. With but slight repairs they lasted for the entire job and were raised on an average of twice a week. The outside forms for the pilasters were built up in 8 ft. sections and left in place for the full height of the walls, but those used to form the insulating space were made in 4 ft. sections and raised at the same time as the wall forms.

Ceiling forms were hung from the trusses and the roof forms were supported on the lower chords of the trusses by means of vertical posts.

A 1 : 2 : 4 concrete mixture was used throughout.

Considerable freezing weather necessitated the installation of steam pipes between the 4-in. walls, and the water used for mixing the concrete was heated to almost the boiling point and the proper amount run into the mixer. The correct proportions of sand and gravel were then added to the water and thoroughly mixed, after which the cement was dumped in and mixed sufficiently to insure its proper distribution. By using this method concrete was delivered from the mixer at about 90 deg. F. By taking the precautions noted above no trouble was experienced with frozen concrete. The performance of the plant in preventing loss by melting of the stored ice has been so satisfactory that the owners consider that the economy thus secured pays good interest on the total investment made.

The work was carried on under the direction of W. L. Darling, chief engineer of the Northern Pacific, and the late W. C. Smith, chief engineer maintenance of way. Deeks, Deeks & Smith, St. Paul, Minn., were the contractors, and the consulting engineer was Mr. C. A. P. Turner, Minneapolis, Minn.


RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.
THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

SAND AND COARSE MATERIAL AND PROPORTIONING CONCRETE.

By JOHN A. DAVENPORT, M.Sc. (Vict.), B.Eng. (L'pool.), Assoc.M.Inst.C.E., A.M.I.Mech.E., M.C.I., and S. W. PERROTT, M.A.I. (Dubl.), M.Inst.C.E., M.C.I.,
Professor of Civil Engineering at Liverpool University.

The following is an abstract from a Paper read at the Fiftieth Ordinary General Meeting of the Concrete Institute. We also give a brief summary of the Discussion which followed.

IN correctly-made concrete the amount of sand should be just sufficient to fill the voids in the coarse material, and the amount of cement just sufficient to fill the voids in the mixture of sand and coarse material and to coat all the particles with very thin jointing layers. It is a rational assumption that such concrete will give the maximum of strength with the minimum of cost, and if such assumption be justified by experimental results it follows at once that the proportioning of concrete-forming materials is of the utmost importance. Greater strengths can be obtained by the use of excess of cement, as in the case of the ordinary mix of 1—2—4, but the increase in strength is less than the increase of cost of materials, and is, therefore, only justified in particular cases.

The strength of any concrete will depend not only upon the materials and their proportions, but also upon the method of using those materials. It will be seen that the amount of the variations in size or the grading will depend upon the nature and quality of the work required.

With a view to testing the effect of "proportioning" upon the strength and other properties, and also the cost of concrete, the authors drew up the following series of experiments, the intention being to test compressive strength, modulus of rupture, specific gravity, water resistance, and fire resistance. Various difficulties arose in the course of the work which not only prevented the Paper being presented on the original date, but prevented also the inclusion of specific gravity, water resistance, and fire resistance tests. There were 6 tubes 4 in. by 4 in. by 4 in. and 6 beams 2 in. by 4 in. by 20 in. in each series, the undotted letters being 28-day tests and the dotted letters 3-month tests.

Composition and Age of Test Pieces.

Series	A (28 days)	6 cubes,	6 beams	4 of $\frac{3}{4}$-in. to $\frac{1}{2}$-in. chips, 2 of sand, 1 of cement.
,,	A′ (3 months)	,,	,,	4 of $\frac{3}{4}$-in. to $\frac{1}{2}$-in. chips, 2 of sand, 1 of cement.
,,	B (28 days)	,,	,,	$\frac{3}{4}$-in. to $\frac{1}{2}$-in. chips, sand and cement, accurately proportioned to fill the voids.
,,	B′ (3 months)	,,	,,	$\frac{3}{4}$-in. to $\frac{1}{2}$-in. chips, sand and cement, accurately proportioned to fill the voids.
,,	C (28 days)	,,	,,	4 of $\frac{1}{2}$-in. to $\frac{3}{8}$-in. chips, 2 of sand, 1 of cement.

Series D (28 days) 6 cubes, 6 beams	½-in. to ⅜-in. chips, sand and cement, accurately proportioned to fill the voids.
,, D′ (3 months) ,, ,,	½-in. to ⅜-in. chips, sand and cement, accurately proportioned to fill the voids.
,, E (28 days) ,, ,,	4 of ⅜-in. to ¼-in. chips, 2 of sand, 1 of cement.
,, E′ (3 months) ,, ,,	4 of ⅜-in. to ¼-in. chips, 2 of sand, 1 of cement.
,, F (28 days) ,, ,,	⅜-in. to ¼-in. chips, sand and cement, accurately proportioned to fill the voids.
,, F′ (3 months) ,, ,,	⅜-in. to ¼-in. chips, sand and cement, accurately proportioned to fill the voids.
,, G (28 days) ,, ,,	¾-in. to ½-in. and ½-in. to ⅜-in. chips, sand and cement, accurately proportioned to fill the voids.
,, G′ (3 months) ,, ,,	¾-in. to ½-in. and ½-in. to ⅜-in. chips, sand and cement, accurately proportioned to fill the voids.
,, H (28 days) ,, ,,	½-in. to ⅜-in. and ⅜-in. to ¼-in. chips, sand and cement, accurately proportioned to fill the voids.
,, H′ (3 months) ,, ,,	½-in. to ⅜-in. and ⅜-in. to ¼-in. chips, sand and cement, accurately proportioned to fill the voids.
,, I (28 days) ,, ,,	¾-in. to ½-in., ½-in. to ⅜-in., and ⅜-in. to ¼-in. chips, sand and cement, accurately proportioned to fill the voids.
,, I′ (3 months) ,, ,,	¾-in. to ½-in., ½-in. to ⅜-in., and ⅜-in. to ¼-in. chips, sand and cement, accurately proportioned to fill the voids.

The foregoing series involve 216 test pieces, to which must be added others prepared for water and fire resistance and specific gravity tests, but which could not be tested in the time available.

The preliminary data comprised tests on Portland cement, size of granite chips, volume of chips per batch, percentage volume of voids in chips, sizes of river sand used, volume of sand used per batch, percentage volume of voids in sand, and the volume of cement used per batch. Regarding this latter item, it must be noted that no allowance was made for the excess cement required for jointing, only the amount required to fill the voids being used. Had time permitted it, the correct allowance in each case would have been ascertained and additional tests made therewith. The preliminary data are given below.

PROPORTIONS AND VOLUMES.

Series.	Size of Chips.	Volume of Chips per Batch.	Percentage volume of Voids in Chips.	Sizes of Sand.	Volume of Sand used per Batch.	Percentage volume of Voids in Sand.	Volume of Cement used for Batch.
					Cub. ft.	Per cent.	Cub. ft.
A	¾ in. to ¼ in.	1 cub ft. for set of 6 beams and 6 cubes	—	—*	0·5	33	0·25
B	¾ ,, ½ ,,		43·5	—	0·435	—	0·145
C	½ ,, ⅜ ,,		—	—	0·5	—	0·25
D	½ ,, ⅜ ,,		45·0	—	0·45	—	0·15
E	⅜ ,, ¼ ,,		—	—	0·5	—	0·25
F	½ ,, ⅜ ,,	—	45·0	—	0·45	—	0·15
G	¾ ,, ½ ,, ½ ,, ⅜ ,,	—	42·5	—	0·425	—	0·142
H	½ ,, ⅜ ,, ⅜ ,, ¼ ,,	—	42·0	—	0·42	—	0·14
I	¾ ,, ½ ,, ½ ,, ⅜ ,, ⅜ ,, ¼ ,,	—	42·0	—	0·42	—	0·14

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* Percentage left on sieve—21 per cent. on 20; 45 per cent. on 30; 100 per cent. on 60. The 21 per cent. was very irregular and coarse.

Cement Tests.

7-DAY TESTS.	28-DAY TESTS.
447 lb. per sq. in.	234 lb. per sq. in.
425 ,, ,,	275 ,, ,,
415 ,, ,,	275 ,, ,,
390 ,, ,,	315 ,, ,,
422 ,, ,,	295 ,, ,,
476 ,, ,,	205 ,, ,,
Average 429 ,, ,,	Average 267 ,, ,,

The batches were hand-mixed by engineering (senior honours) students, and as no special means of testing the thoroughness of the mix were adopted, the resulting concrete will probably not compare favourably with machine-mixed so far as uniformity of results go.

The average values of compressive strengths and modulus of rupture are given in the Paper in tabular form, one for one-month and the other for three-month tests.

The ratio of compressive to tensile strength varies more in the one-month than the three-month tests, and is not sufficiently uniform to base any conclusions upon, beyond the fact that such ratio is not constant. It is considered by the authors, however, that this ratio should be more or less constant as the failure, whether compressive or tensile, depends upon the adhesive strength of the cement.

The ratios strength at three months to strength at one month are more or less uniform, more particularly in the case of compressive strengths. In the case of series A, C, and E (1—2—4 concrete), the modulus of rupture appears to increase more rapidly than the compressive strength, while in the other series, with cement accurately proportioned, the compressive strength increases more rapidly than the modulus of rupture, as out of six series only one runs the other way, probably due to rather dry mixing of those three-month test pieces. Owing to the erratic results given by the neat cement test, and the doubt which exists regarding its quality, it is perhaps unwise to do more than give the ratios.

Although the cement tests are unsatisfactory, it will be possible to compare the strengths and costs of the concrete in the different series, as they will probably all be affected to the same extent.

We may consider the connection between cost and composition in the following manner for compressive loads.

Let W be the load in lb. to be carried by a column of l ft. length,
f be the compressive stress in lb. per sq. in.,
b be the side of the requisite square column, then $\frac{W}{f}=b^2$.

$$\text{Volume of column}=\frac{b^2 . l}{144}\text{ cub. ft.}=\frac{W\ .\ l}{144 . f} \qquad (1)$$

Now for any particular set of conditions we have $W=\text{constant}$, $l=\text{constant}$. $144=\text{constant}$, so that (1) may be written—

$$\text{Volume of concrete}=\frac{k}{f} \qquad (2)$$

Now let C be the cub. ft. of cement per cub. ft. of aggregate as given in the table of preliminary data, and $K=1+\text{volume of sand required per cub. ft. of aggregate}$, then the volume of cement per cub. ft. of concrete is given by—

$$\text{Volume of cement } \frac{k}{f}C\text{ cub. ft.} \qquad (3)$$

$$\text{and the volume of coarse material}=\frac{k}{f}K\text{ cub. ft.} \qquad (4)$$

Expressions (3) and (4) are not quite true, as they are based upon the assumption that 1 cub. ft. of coarse material produces 1 cub. ft. of concrete and no more; but as all the results will be affected alike, the final figures may be safely compared. If we now take the cost of sand and coarse material at 4d. per cub. ft., and that of cement at 19d. per cub. ft., the costs come out as follows:—

$$\text{Cost of cement}=\frac{19kC}{f}\text{ pence} \qquad (5)$$

$$\text{Cost of aggregate and sand} = \frac{4kK}{f} \text{ pence} \tag{6}$$

and the total cost of the concrete-forming materials to carry the required load is—

$$\text{Total cost} = \frac{k}{f}(19C + 4K) \tag{7}$$

For purposes of illustration k may be taken as 10,000, and then C and K from the table of preliminary data, and f from the table of average stresses. Inserting these values in (7) the costs become—

Series.	C.	K.	*f*.	Total Cost in Pence.	$\frac{\text{Cost of cement}}{\text{Total cost.}}$
A	0·25	1·5	854	125·94	0·442
A′	0·25	1·5	1,597	67·08	0·442
B	0·145	1·135	927	91·48	0·324
B′	0·145	1·435	1,062	80·04	0·324
C	0·25	1·5	896	120·09	0·442
C′	0·25	1·5	1,734	62·38	0·442
D	0·15	1·45	790	109·54	0·330
D′	0·15	1·45	1,376	62·84	0·330
E	0·25	1·5	647	166·30	0·442
E′	0·25	1·5	1,023	104·14	0·442
F	0·15	1·45	455	190·30	0·329
F′	0·15	1·45	1,094	79·05	0·329
G	0·14	1·425	640	131·53	0·322
G′	0·14	1·425	1,297	64·82	0·322
H	0·14	1·42	768	108·66	0·319
H′	0·14	1·42	1,261	66·13	0·319
I	0·14	1·42	725	115·07	0·319
I′	0·14	1·42	873	95·56	0·319

The most important point brought out by the above table is the fact that for accurate proportions, the ratio $\frac{\text{Cost of cement}}{\text{Total cost}}$ is practically constant for all the gradings taken in the tests, so that when the graded coarse material is used the total cost need only be further considered. Of course, the total cost is always the final criterion as regards economy, and it may be suggested that the ratio cost of cement to total cost need not be considered. But the relative values of total cost given in the above table may be altered when additional tests are made at other ages, and it is difficult to say whether they will be affected by the ratio, so that if it can be shown conclusively that this ratio is constant, or nearly so, the total cost, age, and proportions need only be dealt with.

DISCUSSION.

Mr. H. Kempton Dyson (Secretary of the Institute) asked, on behalf of Mr. Charles F. Marsh, M.Inst.C.E., if, in the equation showing how the volume of cement per cu. ft. of concrete was arrived at, the author would fill in the gaps in order to indicate how the result was obtained, as he (Mr. Marsh) had not succeeded in getting that result himself. With reference to the table immediately following, he inquired whether the extra cost of grading material was specially included. In regard to Table 1 (series A and B) he pointed out that there was no stuff of ½ in. to ⅛ in. mentioned, and that material he considered most valuable.

Mr. S. Bylander stated that the results obtained were rather lower than those generally anticipated for concrete. That probably accounted for the fact that in actual practice they did not get so good a result as some laboratory tests had shown. He would like to know the quality of the cement, as that always governed the result of the tests, and it was important to state definitely whether the cement was of such a quality as would correspond to the best standard cement usually used.

Mr. Morgan E. Yeatman, M.A., associated himself with the opening remarks of Mr. Bylander, and said that they had not all sufficient time at their disposal to carry out such experiments as had been undertaken by the authors. He thought there must have been something peculiar about the strength of the cement for the authors to have got such low results, which did not increase at three months. Personally, he did not know any concrete which was not stronger at three months than at one month, and out of the nine different classes which were tested, apparently four were worse at three months than at one as regards rupture. As to the proportioning, the idea appeared to have been to show whether, by using different sizes, a better result could not be obtained with less cement. Generally they could do so, but if they compared the proportions given by the authors in a diagram, they would find that they had mixed pieces from ¾ in. to ½ in., ½ in. to ⅜ in., and ⅜ in. to ¼ in., and the smallest as compared with the largest sizes were only half the linear dimensions. In the diagram the small pieces which were employed to fill up the holes between the largest ones were only about one-sixth the dimensions of the latter. Three sizes of material were given to fill up, but where the smallest were only half the size of the largest it could not be done. He did not think the range over which the grading was done would give any practical results.

If the voids were 43 per cent., they ought to have 50 per cent. of sand. There should be at least half as much sand as stone. He did not think they could get an ideal cement by putting 45 per cent. of sand when the voids were 45 per cent. To get all the voids filled they must, in each case, have a little margin, and, that being the case, he did not think they had got the full benefits of the results which they might have done.

Mr. T. A. Watson, Assoc.M.Inst.C.E., said he thought there must be something radically wrong with the concrete to give such extraordinary results as those obtained, as an average of 429 lb. per sq. in. on a 7-day test, and only 267 lb. per sq. in. on a 28-day test. That was not what they had been led to expect from concrete.

With regard to the beam tests, he could not exactly see the object of that. He was greatly disappointed with the actual results and did not think that the final conclusions arrived at were at all satisfactory.

Mr. Allan Graham, A.R.I.B.A., thought the paper required a little consideration before discussing it, in order to be fair to the authors. If the data given were all carried out under the same principles, they might be such as to build a theory upon, and for that reason, if they had a lot of cubes made by the same pupils, and saw the results which were brought forward, they could draw certain conclusions from them. A great many of the test cubes of concrete and cement were so perfectly made by experts that they never got conditions quite equal, and that was why he considered that cubes made by students were just as likely to be equal to those ordinarily used in buildings.

Mr. Henry L. Harding inquired if the aggregates were perfectly dry. If so, the voids would be very much altered. On the other hand, when they mixed up with the water, there would be a certain amount of absorption in the hydrogen, and he thought that chips would absorb a greater amount of moisture than ordinary ballast

The President remarked that if the seven-day tests were neat, and the 28-day tests were 1 to 1, and the sand used was the size as stated, then it showed that the 28-day tests were about correct, and that would account for the low tests that had been obtained subsequently.

Another matter that would account for some of the tests—especially the compressive tests—was due to the fact that wooden moulds were used. It was almost a physical impossibility to get a die square cube out of a wooden mould. The only way in which it was possible to get a fair result, especially under the crushing machine, was that all the surfaces of the cubes that were in contact with the steel plates should be rubbed down until absolutely parallel, and until that was done they could not depend upon the result.

With regard to the various gradings, a great deal depended upon the amount of labour that was put in the concrete, and the amount of water used in the gauging. If they used a large amount of water they would find, especially with sand, that it carried it down without any labour at all, but if it happened to be a dry mixture it required a maximum of labour to get solidity into the concrete. Density, as a rule, depended very largely, not upon the grading of the aggregate, as upon the amount of labour put into it.

PROFESSOR PERROTT'S REPLY.

Professor Perrott, replying to Mr. Marsh in regard to the size of the materials, said he and Mr. Davenport felt that it was not a case of strength, but of arriving at some conclusions, and that they must have some definite size of material to compare in order to know exactly what was filling the voids. They did not want to be left with a mixture that might range from ¼ in. down to the size of sand, thus leaving them as much in the dark as ever. Nothing was done with regard to extra cost of grading as these materials could be bought in the semi-graded form Eventually they might discover that certain mixtures which did not involve much labour would give the best results, and they should then be adopted.

He agreed with Mr. Bylander that the low results were most disheartening. He was present at the making of the cement briquettes, and probably had a hand in mixing them, so he was sure they were properly rammed home when they were put in the moulds. He had made hundreds of little briquettes of this kind and had obtained various results. He was surprised that the members of the Institute had never come across deterioration in cement at 28 days.

As to Mr. Morgan Yeatman's remarks, it was his (Prof. Perrott's) impression that they got bigger results, and while he did not consider them very satisfactory, the three months' compression test gave decidedly larger results. With regard to the distribution of aggregate, the diagrammatical figure was simply to represent some attempt at filling, which would give the impression of the least amount of void. A large percentage of sand seemed to give very disastrous results. In his experience, broken brick aggregate gave the best comparative results. There was not much to be said for even 50 per cent. of sand. The coarser aggregate was bound to get a little expanded by the sand, but the more sand they had the more the aggregate would be opened up, and the worse the results would be.

In reply to Mr. Watson, the object in making the beams was not to show how weak they would be, but to arrive at the modulus of rupture, which was not to be obtained from compressing cubes.

As to Mr. Harding's inquiry, the coarse aggregate they used was perfectly dry. The sand had about 3 per cent. of moisture, but it was very difficult to arrive at the exact amount, as that required a very careful experiment. If the moisture in the sand had been more than 3 per cent. they might have had unsatisfactory results, because a sand with no moisture in it would lie very much closer together.

He agreed with Mr. Graham that graded sand would give better results than ungraded, but it was impossible for them to deal with anything of that kind in this particular paper.

In conclusion, while expressing his regret at the unsatisfactory results obtained, Prof. Perrott said that he felt in duty bound to bring the paper forward no matter what the results were.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE IN HOTEL EXTENSION AT MARGATE.

THE ever-increasing development of the town of Margate has, amongst other things, necessitated an extension to one of its best-known hotels—viz., the Queen's Highcliffe Hotel. This hotel is situated at Cliftonville on the eastern side of Margate, and occupies an excellent position on the cliffs, standing in its own grounds.

The recent additions include a central block connecting the eastern and western wings. The new building has been built on the Mouchel-Hennebique system of reinforced concrete, excepting only the external walls.

The block measures 85 ft. from front to back by 60 ft. wide, and in front it rises to a height of 86 ft. above foundation level. A special feature of the building is the dome and cupola, bringing the total height of 116 ft. from the foundations. The back portion is rectangular in shape and has a terrace roof, the two portions being separated by a large light-court extending down to the level of the first floor.

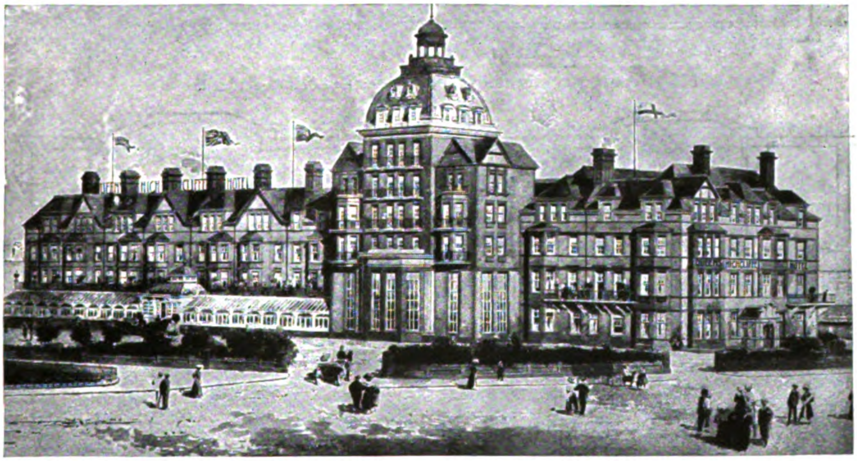


Fig. 1. General View of Hotel as completed.
REINFORCED CONCRETE IN HOTEL EXTENSION, MARGATE.

The use of reinforced concrete offered special structural facilities in this work, inasmuch as a large area was spanned without the aid of intermediary supports. Beams of 55-ft. span carry the floor over the ceiling of the hall from wall to wall. This obviates the use of interior columns which would have been necessary in ordinary methods of construction.

We reproduce herewith an illustration of the interior view of the Queen's Hall, which, with a large ball-room capable of accommodating 400 people, practically occupies the whole of the sub-ground floor. In this view it will be seen that the reinforced concrete beams form part of the decorative scheme. The hall is decorated in the Louis XVI style.

The Tudor Hall, utilised as a dining-room, is over the Queen's Hall and is capable of accommodating 300 guests. The principal structural feature of this room is the floor, which comprises long-span panels on the Mouchel reinforced concrete tubular system, and two main transverse reinforced concrete beams 16 in. wide by 37 in. deep, there being a clear span of 55 ft. These beams are supported by reinforced concrete columns, which are continued upward for the support of the beams carrying the walls of the building above the dining-room. The columns are partly embedded in the walls,

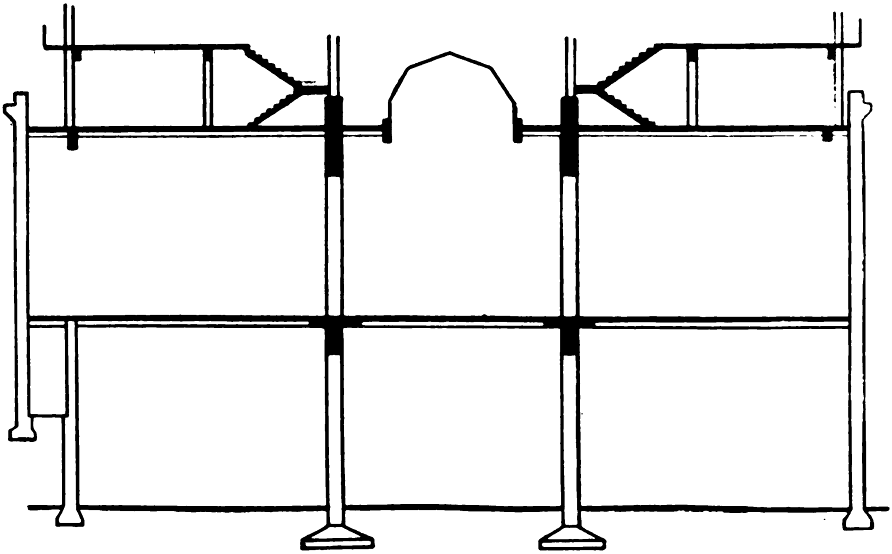


Fig 2. Transverse Section through Queen's Hall and Tudor Hall.

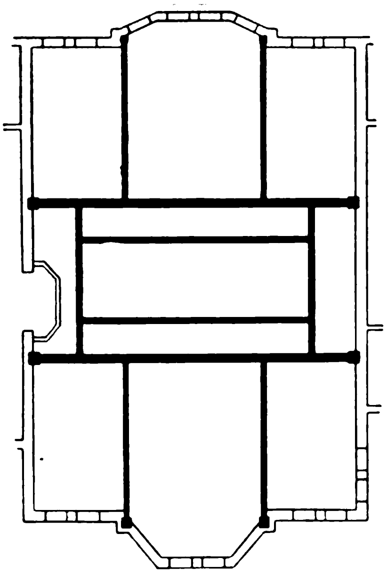


Fig. 3. Plan of Queen's Hall, with beams carrying floor of hall above.

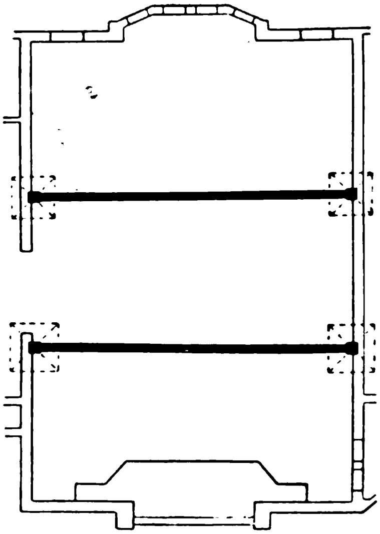


Fig. 4. Plan of Tudor Hall, with beams of floor and lantern above.

REINFORCED CONCRETE IN HOTEL EXTENSION, MARGATE.

the remaining part projecting to form pilasters in the two halls. A short reference should be made here to the dome over the front portion of the building, which includes the sixth, seventh and eighth stories of the front portion. The dome measures

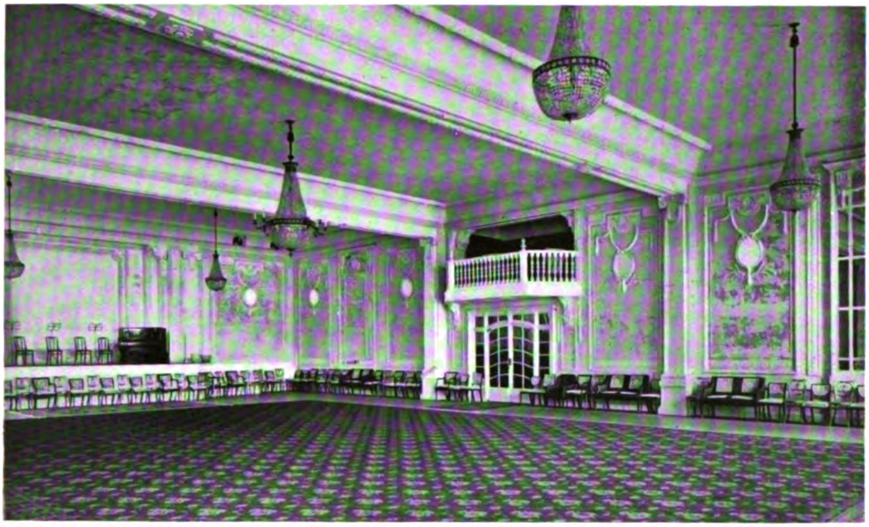


Fig. 5. Interior View of Queen's Hall.

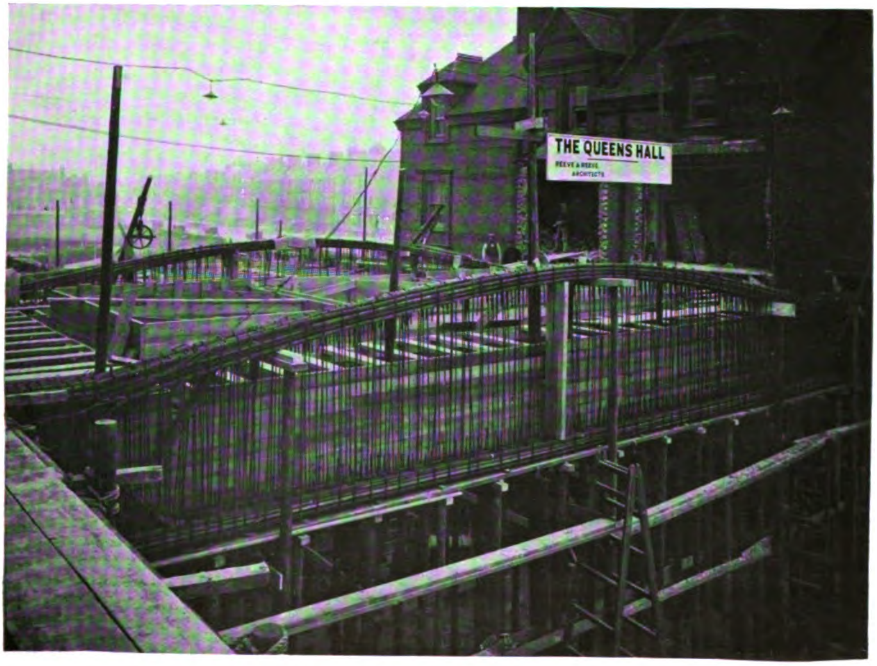


Fig. 6. Reinforced Concrete Beams over Tudor Hall.
REINFORCED CONCRETE IN HOTEL EXTENSION, MARGATE.

31 ft. by 26 ft. in plan at sixth floor level. The shell is of reinforced concrete, and is 6 in. thick. The cupola rises to a height of approximately 18 ft. above the top of the dome; it is 8 ft. in diameter, carried by columns 8 in. square.

This building is another good example of the many advantages of reinforced concrete construction. The architects were Messrs. Reeve and Reeve, Cecil Square, Margate. The reinforced concrete details were designed for the architects by Messrs. Mouchel and Partners, Ltd., of 38, Victoria Street, S.W. The contractors for the building were Holloway Bros., London, whilst the contractors for the decorative work were Messrs. Hampton and Sons.

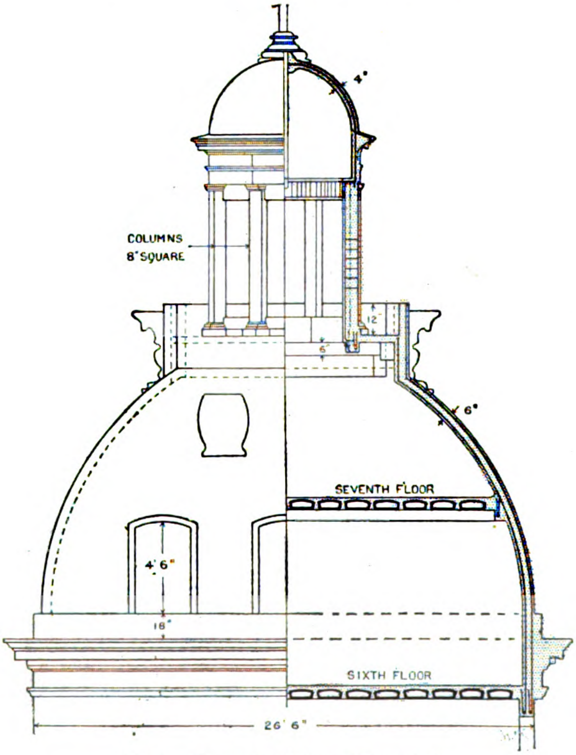


Fig. 7. Dome over Front of New Block.
Reinforced Concrete in Hotel Extension, Margate.

SOME CONCRETE WORKS IN SOUTH AFRICA.

Sea Point Beach Improvement Scheme, Cape Town — This scheme consists of the excavation of a large area of rock on the coast at Sea Point, a marine suburb of Cape Town, the construction of a sea wall and promenade. and providing large bathing pools with a maximum depth of six feet, the floor of these being covered with a concrete floor 6 in. thick; the size of the large pool is 250 ft. by 180 ft. A large pavilion has also been constructed providing 250 dressing cubicles, verandahs, club-rooms, hot-water sea-baths, etc., while the roof provides promenade, band stands, tea-rooms, etc., and on the beach level, the whole expanse under the building, being shaded from the hot South African sun, is principally used by children, while in front of this area is a semi-circular paddling pool with maximum depth of 2 ft.

The sea-wall, walls and floor of pools, and retaining walls are all of mass concrete mixed in proportion of 5 parts 2-in. stone, 2½ parts sand, to 1 part English Portland cement (by measure), whilst the pavilion is built entirely of reinforced concrete from the Kahn system. The whole of the stone required for the work was provided from the rock excavations, was broken on the site by a small "Mason" crusher driven by a 10 h.p. electrical motor, and the concrete mixed by a Ransome batch mixer driven by 7 h.p. petrol engine. All concrete for reinforced work was mixed in proportion of 3½ parts ¾-in. stone, 2 parts sand, and 1 part English Portland cement.

The whole of the work was completed in twelve months, with the exception of a reinforced concrete foot-bridge, which is at present in course of construction. The total cost is £16,000. Messrs. Murray and Stewart carried out the buildings for the city of Cape Town.

The engineers are Messrs. Cherry and Nesbit Roberts, and the reinforcement was supplied by Messrs. Warden Foote and Co., the Cape agents for the Trussed Concrete Steel Co.

Reconstruction of Gilfillan Bridge, Cradock, Cape Province, S.A. – This structure, part of the main street of the town, spans the Great Fish River and displaces a steel bridge of curious design, being of one continuous span of 180 ft. supported in the centre by a masonry pier and having masonry abutments.

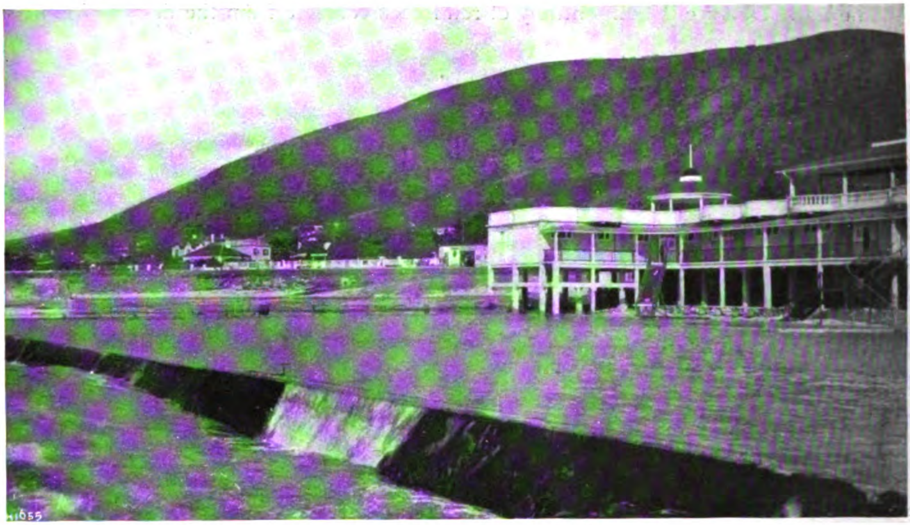
The new structure is built entirely of reinforced concrete from the designs from the Public Works Department, Union of South Africa, and consists of four continuous spans of 50 ft., with a carriage way of 22 ft. wide and two footpaths of 4 ft. 6 in. each. The main reinforcement of piers consists of 2½-in. round mild steel rods, the length of which averages 43 ft. The beam reinforcement is mostly of 1½-in. round rods, while the road slab is of ½-in. longitudinal rods and ⅝-in. transverse. The plinths, footway slabs and parapet are all unit construction prepared early in the job, the reinforcement of the two latter being No. 9 expanded metal. The concrete throughout was mixed in proportion of 3½ parts ¾-in. stone, 2 parts river sand, and 1 part English

View of Completed Reinforced Concrete Pavilion, with large bathing pool in foreground.

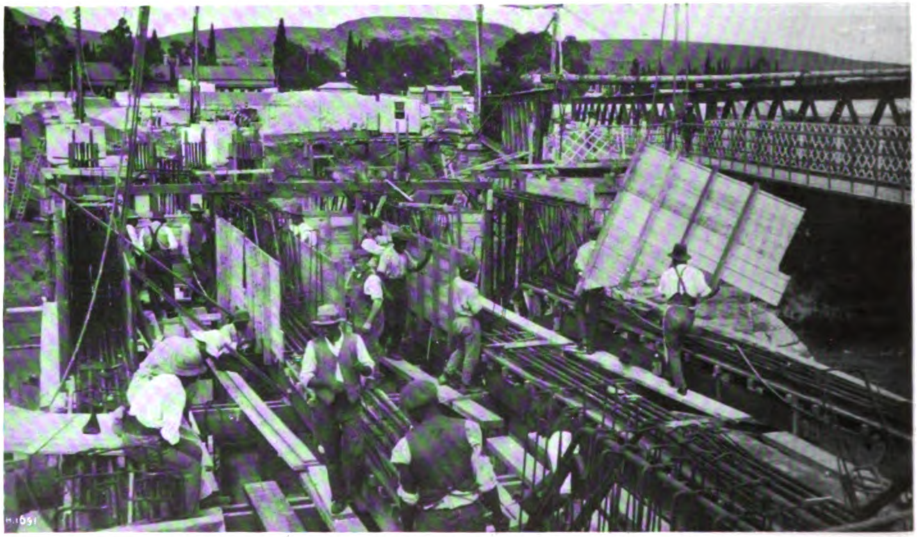
View showing the Placing of Concrete on the Promenade Floor.

SEA POINT BEACH IMPROVEMENT SCHEME, CAPE TOWN.

Portland cement (by measure). The mixer used was a Ransome batch mixer with petrol engine as motive power, which power was also used throughout the work for pumps, circular saw, stone and sand-washing plant, etc., and the concrete was conveyed



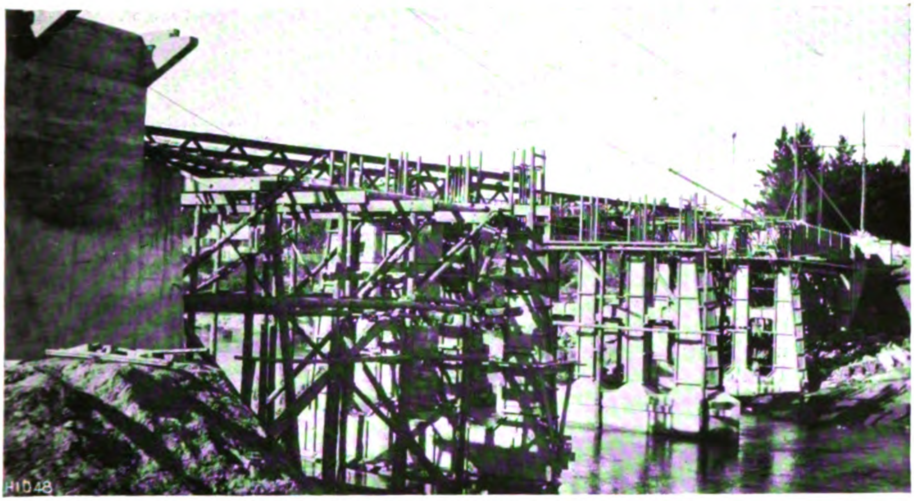
View showing Completed Sea Wall.
SEA POINT BEACH IMPROVEMENT SCHEME, CAPE TOWN



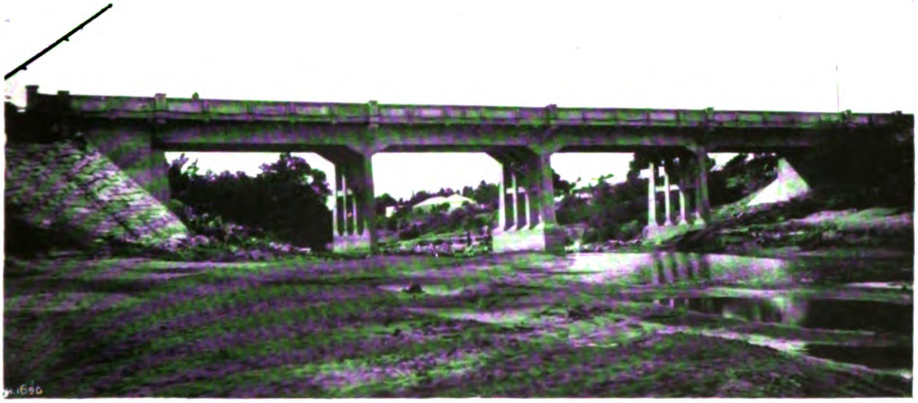
View showing Beam Reinforcement and Fixing Forms (sides).
GILFILLAN BRIDGE, CRADOCK, SOUTH AFRICA.

by tip-trucks direct to the "schutes," which placed the material right in position, four or five men with specially shaped iron tools working the concrete round the reinforcement at the bottom of each "schute."

All foundations were carried down to rock some ten feet below river bed, the excavations being sheet piled and kept dry with two 3-in. centrifugal pumps. The river, like all Karoo rivers in South Africa, remains for long seasons very low, and at times comes down with great velocity sometimes to a depth of ten or fifteen feet, so that it was necessary to carry out the staging for two centre spans in the form of a large framed truss. The forms were constructed so that sides of beams could be removed early, leaving the soffits. These sides were removed in one week, and the staging and soffits of beams in 28 days. An overhead ropeway (of $\frac{5}{8}$-in. steel hawser) was thrown across the river, which was found very useful during construction, as was another for the demolition of the old bridge, alongside of which the new structure was built.



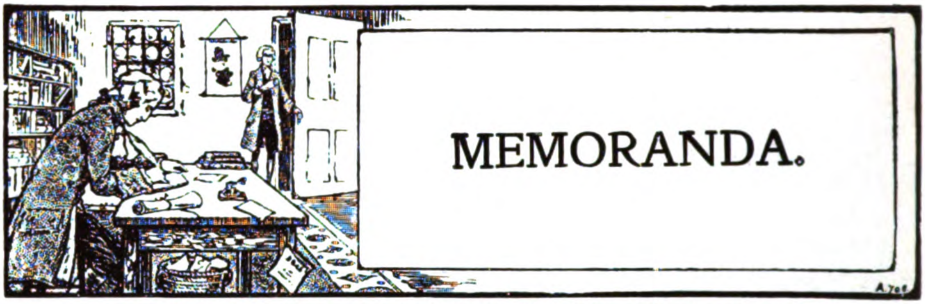
View showing Pier Construction.
GILFILLAN BRIDGE, CRADOCK, SOUTH AFRICA.



View of Finished Reinforced Concrete Bridge.
GILFILLAN BRIDGE, CRADOCK, SOUTH AFRICA.

The work was completed in twelve months, and the total cost was £12,000.

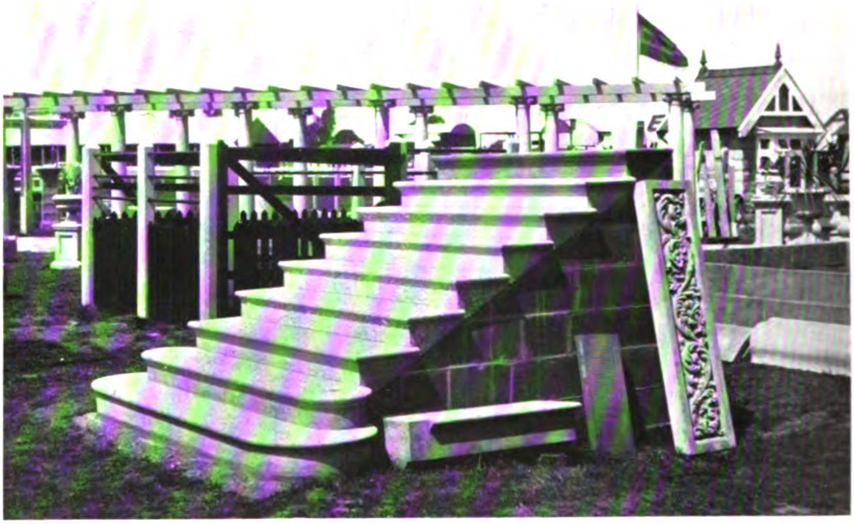
The contractors were as before—Messrs. Murray and Stewart. The work was executed for the Public Works Department, Union of South Africa, Mr. W. W. Tonkin being the district engineer.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Royal Agricultural Show at Shrewsbury.—The Stand of the Associated Portland Cement Manufacturers (1900), Ltd.—At a time when so much interest is being evinced in the use of concrete for purposes other than those of large buildings, it may not be out of place to make some special mention of the concrete exhibits at the Royal Agricultural Show, which was held at Shrewsbury last month. One of the principal features at the Royal Show was the collective exhibit of the Associated Portland Cement Manufacturers (1900), Ltd., arranged by Mr. G. W. Butchard, and it was an excellent example of the adaptability of concrete for every purpose on the farm and estate.



CONCRETE STAIRCASE EXHIBITED AT THE ROYAL AGRICULTURAL SHOW, SHREWSBURY.

The exhibit occupied a good and conspicuous position, somewhat isolated from the other stands, and comprised a two-storey house built of hollow concrete blocks and farm buildings of reinforced concrete suitable for a small holding. This is being taken over by the Shropshire County Council. As it is intended to publish a short illustrated article regarding this homestead in a subsequent number, we are holding over all further particulars regarding same as to contents, method of construction, cost, etc.

On the stand itself were also exhibited many concrete articles of interest to agriculturists and others which had been contributed by various firms. Messrs. Siegwarts, Ltd., sent concrete telegraph poles and water and sewage pipes. Messrs. Sharp, Jones

General View of the Stand of the Associated Portland Cement Manufacturers (1900), Ltd.

THE ROYAL AGRICULTURAL SHOW, SHREWSBURY.

and Co., of Parkstone, Dorset, sent in a large manhole, soft or rain water tank supported by concrete piers, and inspection drainage chamber, storage tank, cattle mangers, etc. There were concrete signposts, lampposts, fencing and gateposts, posts for fruit trees, garden seats, etc., sent by Messrs. Tidnam, Ltd., of Wisbech. This same firm also supplied the concrete fencing for two sides of the stand.

The Reinforced Concrete Fence Post Co. contributed a cattle-pen with concrete posts and tubular rails and various types of fencing; whilst some very effective concrete ornamental vases on pedestals, a garden frame and tanks were sent in by the Old Radnor Trading Co., Kingston, Hereford, who were also responsible for the rose-covered concrete pergola which was a pleasing feature of the stand.

A concrete flight of stairs illustrating various finishes with different aggregates was erected by the Patent Impervious Stone Co., London. Another feature of interest was a pavilion erected on pillars made of blocks from a Winget machine. Inside the pavilion were ornamental panels of different aggregates. Some interesting statues in concrete by Bryans Adamanta, Ltd., Birmingham, were also shown, and tanks and manhole covers by Herbert Todd and Co., Westminster.

Stuart's Granolithic Co. sent fine examples of balustrades, vases, paving, etc., and Bell's United Asbestos Co. provided the "Poilite" tiles and sheets for the roof of the pavilion.

Winget machines for making blocks and drain tiles and a Baumgarten machine for making roofing tiles were in operation.

The stand was in every respect not only most interesting, but exceedingly instructive. We produce herewith a general view of the stand and also illustrations of some of the exhibits shown, and, as stated above, we hope to give a short article in our next issue on the homestead, only briefly referred to in this memorandum.

VARIOUS CONCRETE EXHIBITS AT THE ROYAL AGRICULTURAL SHOW AT SHREWSBURY.

CONCRETE ON THE FARM AND ESTATE EXHIBIT AT THE ROYAL AGRICULTURAL SHOW, SHREWSBURY.

Concrete Breakwater at Glenelg, South Australia.—The South Australian Government, having decided to call for tenders for the much-required breakwater at Glenelg, the leading watering-place of the State, permitted the tenderers to submit costs for either reinforced concrete or timber-piled work, and several firms submitted prices for one or both methods. The design and price of Messrs. Stone and Sideley, concrete and constructional engineers, of Geelong, Victoria, was accepted, with certain suggestions of the State Engineer-in-Chief, Mr. Graham Stewart, which increased the price by £4,000 and to a total of £32,000. The breakwater, as designed by the above firm, is described as a series of reinforced concrete caissons connected by girder and lattice work, with a receiving curved face giving an arc of about 75 degrees, receding from half-tide line to an outward angle at the summit, or upper edge. This breakwater is to provide shelter for yachts and other small craft, and is expected to provide ample protection against the so-called "Southerly Busters" that have hitherto cast most of the boats ashore.

A previous attempt was made to provide a breakwater in the same locality, but was abandoned. It was specified for concrete piling under the conditions of the Department, but the piles either buckled under the hammer or were so fractured that the first heavy sea broke them off. There does not appear to have been any official reason given of the cause of failure.

We hope to publish further particulars of this work later on when it is well in hand.

Concrete Blocks at Goodwick.—The extensive alterations which are being effected at Fishguard Harbour to make it a more suitable port of call for the American liners will necessitate the use of much concrete work, and the firm which has the contract in hand, Messrs. Topham, Jones and Railton, has erected temporary works along the Goodwick beach, at which huge concrete blocks, weighing several tons, are being cast.

In order to move the casting cases about, as required, one of the largest cranes ever seen in this country has been requisitioned by the firm, and our illustration shows it in the act of lifting one of these cases.

Concrete Block Work at Goodwick.

Reinforced Concrete Pontoon in Australia.—A reinforced concrete pontoon has been constructed to the order of the Sydney Harbour Trust by Messrs. Stone and Siddeley, of Sydney, Melbourne, and Geelong. The pontoon is to be placed in position at the eastern end of Circular Quay for the use of the Lavender Bay and Parramatta River ferry services.

The dimensions of the pontoon are:—100 ft. in length, 53 ft. 3 in. wide at one end, and 67 ft. 7 in. at the other, depth 7 ft. 9 in., with a 32-in. freeboard. The bottom is flat and the sides and ends are sloped to an angle of 70 deg. Special attention has been given to the design of the steel work with a view to enable the construction to withstand the excessive strains likely to occur should vessels be berthing at each side of the pontoon at the same moment. In the construction of the top and bottom of the pontoon allowance has been made for a live load of 150 tons, which will be distributed over the centre length between the posts. The pontoon has been constructed of ½-in. blue metal concrete reinforced with steel bars. The whole construction is divided into 48 watertight compartments, and weighs about 650 tons.—*Commonwealth Engineer.*

Reinforced Concrete Door in a Racket Court.—Major A. R. Winsloe, writing to the *Field*, states that he has experimented with reinforced concrete doors in racket courts in India, where much difficulty is experienced with open-air courts where wooden doors

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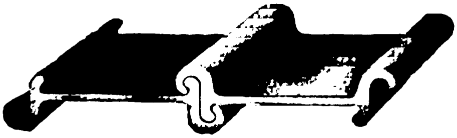

THIS IS AN ACTUAL RECORD OF THE DRIVING OF THIS PILING AT THE FRENCH WEIR CONTRACT AT TAUNTON LAST JUNE.

Number of piles driven	289
Lengths of piles	12 to 18 ft.
Section of piles	8 in. by 22 lb. & 12 in. by 27 lb.
Total lineal feet driven	4416
TIME	SIX DAYS
COST OF DRIVING	1·38d. per super ft.

(This figure includes labour, coal, oil, proportion of supervision and establishment charges.)

THE HAMMER USED WAS A No. 5 McK.T. AUTOMATIC

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Telegrams—"PILINGDOM, LONDON." Telephone—AVENUE 5463 (5 lines).

are used, owing to the warping of the wood. He says he has recently fixed up a reinforced concrete door in one of the courts at Lucknow. It acts excellently and the ball bounces perfectly on the concrete surface. The door, which is 3 in. thick, is hinged to a vertical steel spindle and moves on a racer on the floor. It is therefore not difficult to open or shut, in spite of its weight. With the skilled workmanship available at home a very perfect door should be possible. False bounds would then be things of the past.

Reinforced Concrete Posts for Vineyards.—The *Tonindustrie Zeitung*, in a recent number, gave an interesting article on the use of reinforced concrete posts in the vineyards abroad. These posts are replacing the old wooden posts, and are proving eminently satisfactory. Amongst the advantages put forward in support of their use, it is stated that it is possble to make them to any desired shape and strength. Everywhere where reinforced concrete posts have been used in the vineyards they have met with approval. Of course, their greatest advantage consists in their durability and powers of resistance, whereas the wooden posts suffer from weather conditions, and the dampness of the ground rots them. Similar and other objections are raised against metal posts. Again, it is possible to bed the concrete posts into the ground very firmly, and this is an important factor when cutting the ripe fruit, as those berries not sufficiently ripened are not so liable to be shaken off. Further, concrete posts are of great assistance to the vineyard owner in keeping at bay some of the destructive agents which attack the vine and spoil the fruit. It is known that wood harbours the worm and other insects which attack and spoil the fruit. The writer of the article concludes by saying that these installations of concrete posts are also most pleasing and decorative in appearance. They are joined by means of wire drawn from post to post.

CORRESPONDENCE.

To the Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

A Bending Moment Problem.

SIR,—Referring to the above solution, it may be of interest to some of your readers to know that the general solution of the positions of props to give greatest strength of beams will be found in a small work entitled "Introduction to the Mathematical Theory of the Stress and Strain of Elastic Solids," by B. Williamson (Longmans and Co., 1894). The particular solution given by your able contributor* is not in the work I have just mentioned, but, of course, it can be derived from the general treatment.

Yours, etc.,

Limerick, June 25, 1914. DE SILVA.

* The above letter refers to an article which appeared in our June No., p. 404.

TRADE NOTICES.

The United States Steel Production Company.—The announcement is made that the United States Steel Corporation and its subsidiary companies propose to have a comprehensive exhibit of its operations at the Panama-Pacific Exposition in San Francisco in the year 1915. It will begin with the ore fields and carry on an educative picture of its operations in ore mining, rail and water transportation, dock operations, coal, coke and pig iron production, steel manufacturing in its various lines, and will also present in a materially displayed way the processes of manufacturing of many of its subsidiary companies' products, also how it utilises its by-products and the display of many of the uses in which its general products are employed, typifying the advancement in the uses of this country's resources

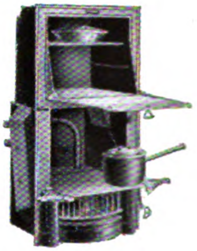
In addition to the material exhibits before mentioned, the Corporation intends to exhibit in a comprehensive manner, by moving pictures, its operations throughout all departments, showing the ramifications of the processes of the Corporation's operation. It is proposed as well to set forth to the world the work which the United States Steel Corporation has done toward the social welfare of its employees and those depending upon them. Also it will exhibit many forms of safety devices that have been conceived by the Corporation officials and its employees and in the installation of which large sums have been, and are being, expended by the Corporation. In this social welfare department will also be shown the methods employed by the Corporation in the aid and care for the injured and the welfare of employees' conditions at work and the benefits that are aimed to be afforded to employees at their work and in their surroundings. Also the voice that is given to the employees through their committees in bringing about these improved working conditions and the general plans of the Corporation's methods.

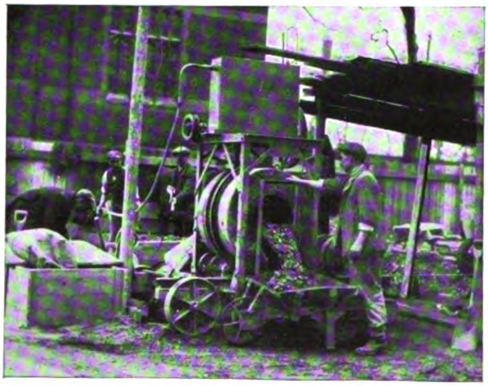
General Fireproofing Co.—We understand that Trussit walls and partitions and self-centering ceilings and roofs have been adopted for the construction of the new King Edward Memorial Sanatorium at Pont-y-Wal, South Wales. The architect for this building is Edwin T. Hall, Esq., the well-known hospital specialist. We also understand that this construction of the General Fireproofing Co.'s has been specified for a large number of other sanatoria, as well as factories, power stations, etc.

Claridge's Asphalte.—Among many contracts in hand, Messrs. Claridge's Patent Asphalte Co., Ltd., have the following—viz. :—H.M. Stationery Office, Stamford Street, S.E., 70,000 ft. of asphalte roofing; British-American Tobacco Company's warehouse, Millbank, S.E., damp courses, floors, and roofs; Messrs. W. H. Smith and Sons' new Printing Works, Stamford Street, S.E., damp courses and roofs.

"Simplex Concrete Piles" is the title of a little volume just issued, containing interesting illustrations and particulars of some of the recent work executed on the "Simplex" system of concrete piles, and claims, amongst other practical advantages of the system, that a considerable saving of time is effected owing to the piles being driven and constructed by practically the same operation, no time being lost in casting piles some months before the actual driving commences. The brochure is issued by Messrs. Simplex Concrete Piles, Ltd., Caxton House, Westminster, S.W.

"The Interoven" Stove (Pascall's Patent).—This useful stove, which is easily converted from a cooking stove into a parlour grate, recently obtained the Highest Award (Silver Medal) at the Royal Sanitary Institute Exhibition at Blackpool. It should be an ideal stove for cottages, bungalows, etc. Our illustrations show the stove as sitting-room grate and as cooking stove. The sole manufacturers are the Interoven Stove Co., Ltd., 156 Charing Cross Road, London, W.C.





THE
VICTORIA
CONCRETE MIXER

1. Centre Ring Construction.
2. External Discharge Chute.
3. Drum $\frac{1}{4}$ in. Steel Plate.

The VICTORIA is designed for fast and efficient mixing. It will mix concrete faster than you can get rid of it.

The VICTORIA
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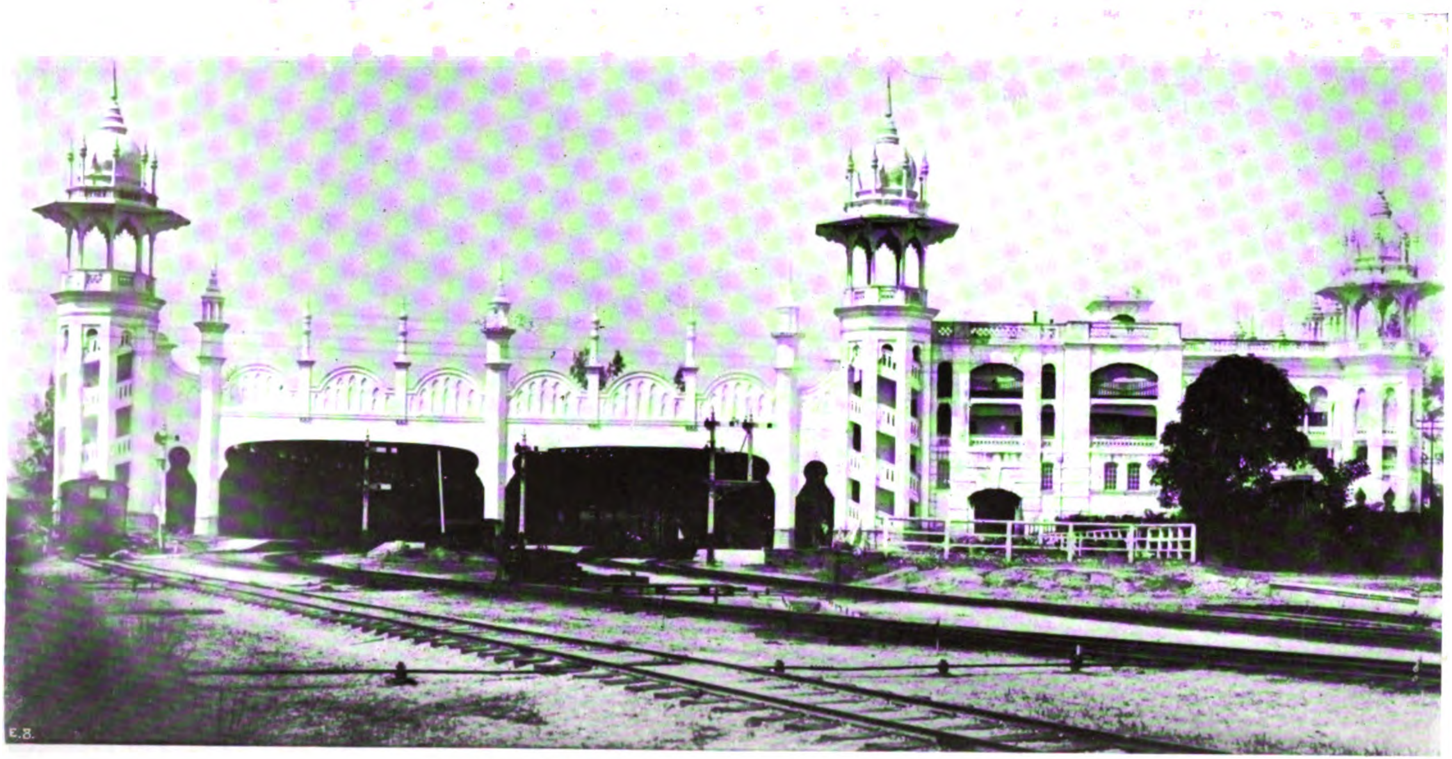
WRITE FOR CATALOGUE No. 29.

THE
T. L. SMITH Co.
13, Victoria Street, S.W.



The Railway Station, Kuala Lumpur, Federated Malay States.
(Recently enlarged.)
(See page 604.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume IX. No. 9. LONDON, SEPTEMBER, 1914.

EDITORIAL NOTES.

THE CONCRETE INDUSTRY AND THE WAR.

PRACTICALLY a month has now elapsed since the first black clouds of war loomed dark on the horizon and that eventually war broke out. The disorganisation of business which naturally arose at the first news has more or less abated. The money market, trade, commerce, industry were for a short while paralysed and indeed seriously threatened, but, thanks to the efforts of those in charge of our affairs, things have steadied themselves, and business is, as far as possible under war conditions, assuming its natural course.

Whatever the ultimate result of the war may be, one thing is certain, and that is, much hardship and suffering will have to be endured. But, as has already been pointed out so ably in our daily and technical Press, those who are left at home to conduct our affairs and carry on the daily business can do much to allay suffering—nay, more, can to a great extent arrest the stagnation of industry and trade, by exerting all their efforts in the direction of "keeping the ball rolling."

Already one result of the war has been the termination of the building strike. Thus thousands of men were able to return to work, and this termination of a most unfortunate dispute should give impetus to the building trade as a whole.

Further, it is with great satisfaction that we learn that the Government and the various municipal authorities are about to put into immediate operation the much-needed schemes for rural housing.

And now, turning to the special industries in which we are interested and whose welfare we desire to promote—viz., the cement and concrete industries—we would like especially to address the concrete industry as a whole, and urge upon all those firms interested the necessity of acting loyally by keeping the industry going.

This should, in effect, not be so very difficult for this particular industry—in fact, less so than for many others. We have in this country ready to our hands large cement factories ready and willing to turn out the cement. And even if one or two foreign markets may be closed for the import of concrete machinery, concrete blocks, tools, etc., there still remains open the large American market to draw upon for the time being, till we make similar machinery and tools ourselves.

In every direction it is the extension of building work at home which should receive paramount attention, even if at times conducted with difficulty. We should, and will, doubtless benefit to a large extent, for example, by the various housing schemes now about to be put into operation. For, as has been shown so often in these pages that it is almost needless to reiterate it at this time, cement and concrete should and will play a large part in solving this most difficult of problems—the better housing of our working classes.

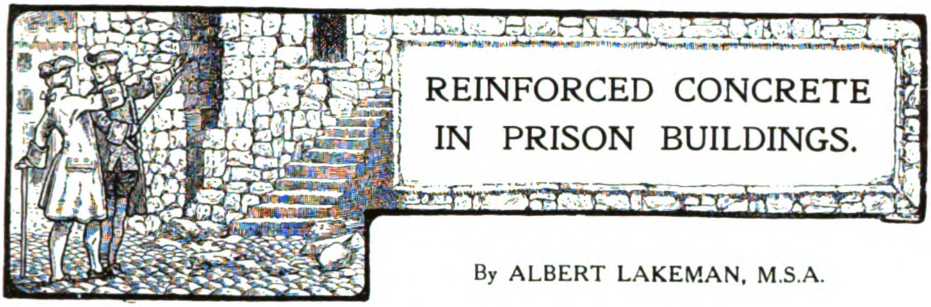
Again, it has been shown by practical application how useful and advantageous concrete construction has proved in our dockyards, arsenals, naval bases, and for defence work generally, and its use in this direction will surely be more extended in the future. Again, we recall the many Government buildings, large factories, business houses, warehouses, etc., where concrete has been applied with advantage and to the satisfaction of those who adopted this form of construction. Also we note with pleasure the preparedness of some of the municipal authorities at any rate to experiment with concrete for our roads.

As to the cement industry *per se*, we wish it every success in capturing the German business that has been such a bugbear to it in several colonies and South America, and we trust there will be a strong move in this direction, with the active co-operation of all concerned, including the Board of Trade.

We look, therefore, to the spirited support of all professional men, masters, manufacturers, and workers at this time to keep the cement and concrete industry alive and active, which, as far as this country is concerned, as well as our various Colonies, has certainly still got a most promising and prosperous future in front of it.

The Paper Famine.

Owing to the scarcity of better class paper suitable for our illustrations, due to the stoppage of supplies from the Continent, we are compelled to cut down the bulk of our journal, and we must ask the indulgence of our readers, who, we are sure, will understand the difficulty under the present circumstances.



REINFORCED CONCRETE IN PRISON BUILDINGS.

By ALBERT LAKEMAN, M.S.A.

In the following article some interesting particulars are given as to the special suitability of concrete for prison and similar buildings.—ED.

Introduction.

REINFORCED concrete offers many possibilities in prison construction, and the extensive use that is now being made of this material indicates that its suitability is realised for this class of work. It has the great advantage that it can be executed by unskilled labour under efficient supervision, and thus it is economical while being strong, fire resisting, and requiring practically no maintenance. It will be readily understood that the problems which Major H. S. Rogers, R.E., the Surveyor to the Prison Commission, has to deal with are quite out of the ordinary and there is no precedent for many of the cases with which he has to deal. There is always the human element to consider in prison work, and the uncertainty of this factor necessitates a great deal of consideration in the design and construction of the buildings. The two examples described herein are typical cases, and they indicate ingenuity well worthy of study.

Wandsworth Prison Workshops.

These workshops are L-shaped on plan, as shown in *Fig.* 1, and they provide accommodation for seventy-five leather workers and two hundred mail bag makers. The shops have a length of 151 ft. 6 in., with maximum width of 100 ft. 6 in. and a minimum width of 67 ft. The rear portion is carried up for the ground floor height only, with 10 ft. 6 in. from the floor level to the underside of the gutters, while the front block comprises ground and first floors, with accommodation for one hundred tailors on the latter, giving a total height of about 24 ft. to the wall plates. The most interesting portion of the construction is provided in the rear portion, where it was essential to provide good light and ventilation combined with the maximum security. This portion is divided up into seven bays longitudinally, each 15 ft. 6 in. wide, and two bays across the building, each 32 ft. wide. The bays are divided by a longitudinal row of columns, which are constructed of concrete 9 in. square reinforced with four ½-in. diameter rods well bound with links at intervals, and these columns are faced with 4½ in. of brickwork all round. Blue Staffordshire bricks are employed for a height of 6 ft., and above this white glazed bricks are used. The reinforcing bars are spread outwards at the bottom and carried well down into the foundation slabs, which are 9 in. thick and 4 ft. square, and reinforced in the lower surface with expanded metal. The lower part of the column below the floor level is formed entirely of concrete and is 1 ft. 6 in. square, this being the size of the concrete

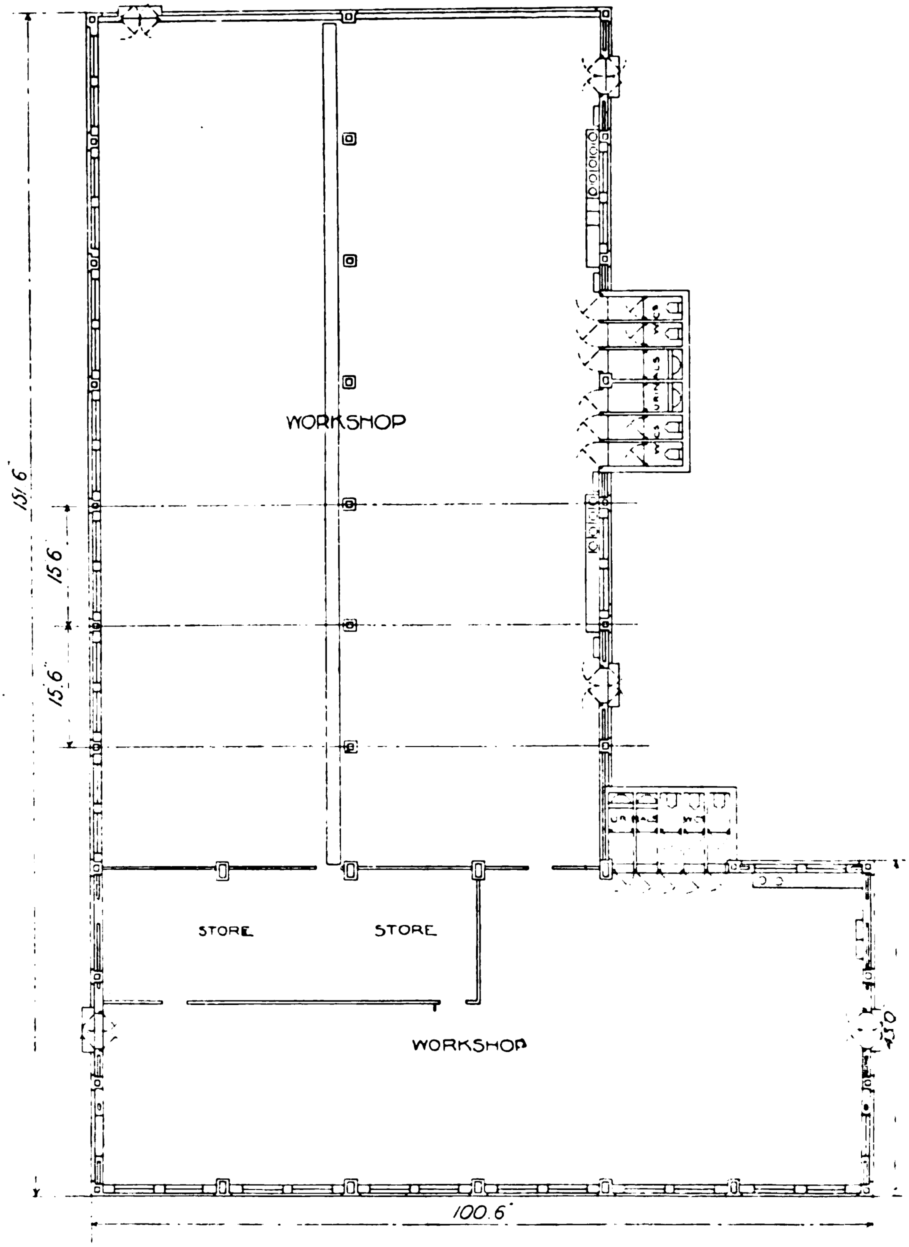


Fig. 1. Ground Plan.
Wandsworth Prison Workshops.

and brickwork combined above. The roofing is executed on the saw-tooth principle, as shown in *Fig. 2*, and it will be seen that large beams occur at a level above the roof and the latter is suspended from them. The beams are of reinforced concrete, and they span across the bays above mentioned, a distance of 32 ft. They are 3 ft. 4½ in. deep and 15 in. wide, with reinforcement consisting of four 1½-in. diameter rods in both bottom and top surfaces, and links are provided throughout for connecting the two sets of rods. These beams were cast on the ground and afterwards raised up to their positions as shown in the photograph in *Fig.* 3, which is a general view during the progress of the work. The higher part of the pitched roof takes a bearing against the lower edge of one beam, and is suspended from the next beam in such a manner that a vertical pivotted light can be introduced between the roof and the beam, as shown in the detail. The sloping roof is formed with 6-in. by 3-in. rolled steel joists at about 6-ft. centres, which support a concrete filling 2½ in. thick reinforced with Hy-rib. The concrete is carried over the steel joists, which are kept up to project above the filling, and the whole surface is asphalted. The gutter at the lower end of each slope is also formed in concrete and reinforced with small longitudinal and transverse rods. The

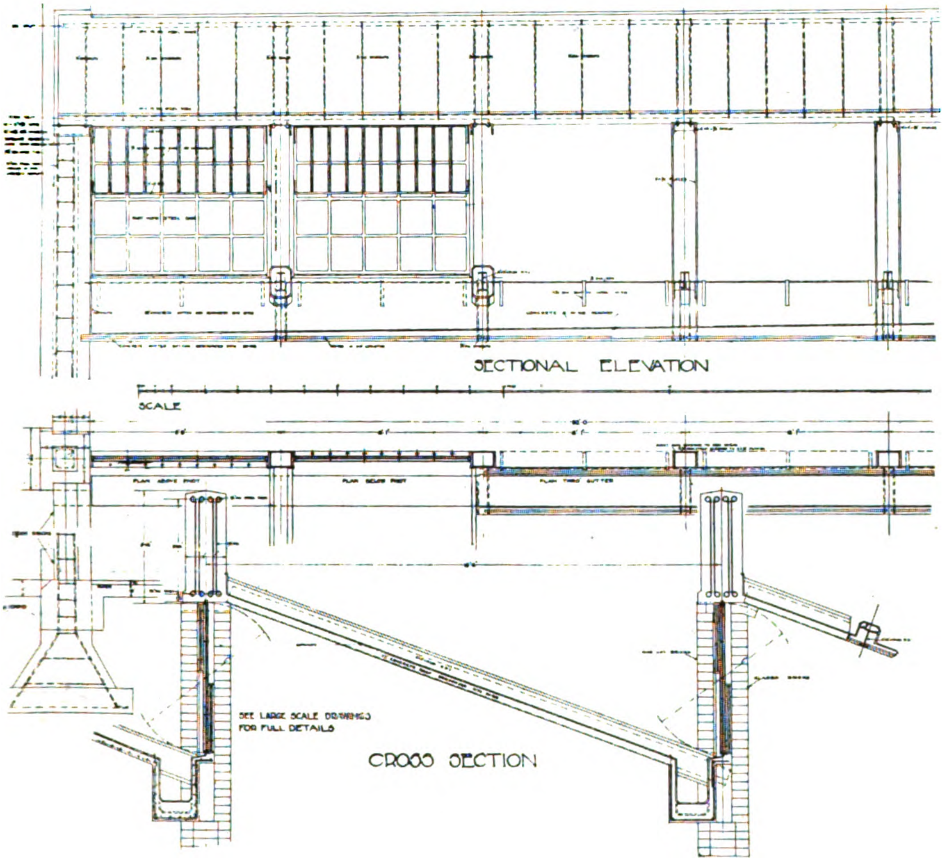


Fig. 2. Details of Concrete Work.
Wandsworth Prison Workshops.

advantage of keeping the beams up in this manner is that they do not obstruct the light or reduce the head-room, and, furthermore, the vertical light is sheltered under the beam and is not exposed to the full force of the weather, while it is very accessible for cleaning purposes. The first floor in the front portion is constructed with Siegwart patent beams, supported on rolled steel joists and plate girders, and the roof is formed with steel trusses having a span of 40 ft.

The workshops have been planned and constructed with plenty of light and ventilation, and are arranged to give the maximum amount of security while rendering the control of the occupants as simple as possible, and they form an interesting example of modern prison work.

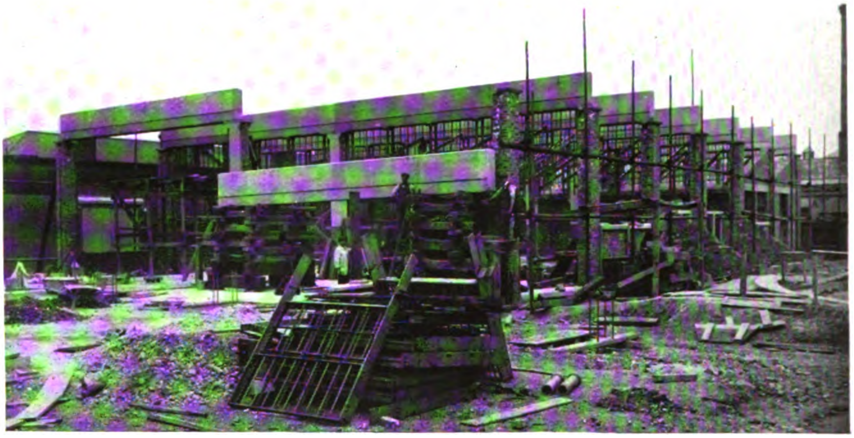


Fig. 3. View of Concrete Beams in Position.
WANDSWORTH PRISON WORKSHOPS.

Borstal Institution, Borstal.

Some further interesting construction is provided at this institution in the work to new carpenters' and smiths' shops which are now being erected. These occupy a space 108 ft. long and 88 ft. 1½ in. wide, the two shops adjoining and each being 40 ft. 9 in. wide in the clear. Lavatory accommodation is provided to each shop by small projecting bays in the centre of each long frontage, and engine space is provided in the centre of the building in such a manner that it serves the two sections. The buildings are divided into seven bays, each 15 ft. wide, and there are no intermediate supports to cause obstruction, as these are arranged to come on the outside walls and between the two shops, leaving a clear space 39 ft. wide. A clear height of 15 ft. is provided in the centre of each shop, and the method of forming the supporting members to the roof is very interesting, as illustrated in *Fig* 4. This shows a section of the carpenters' shop, the smiths' shop being similar, and it will be seen that

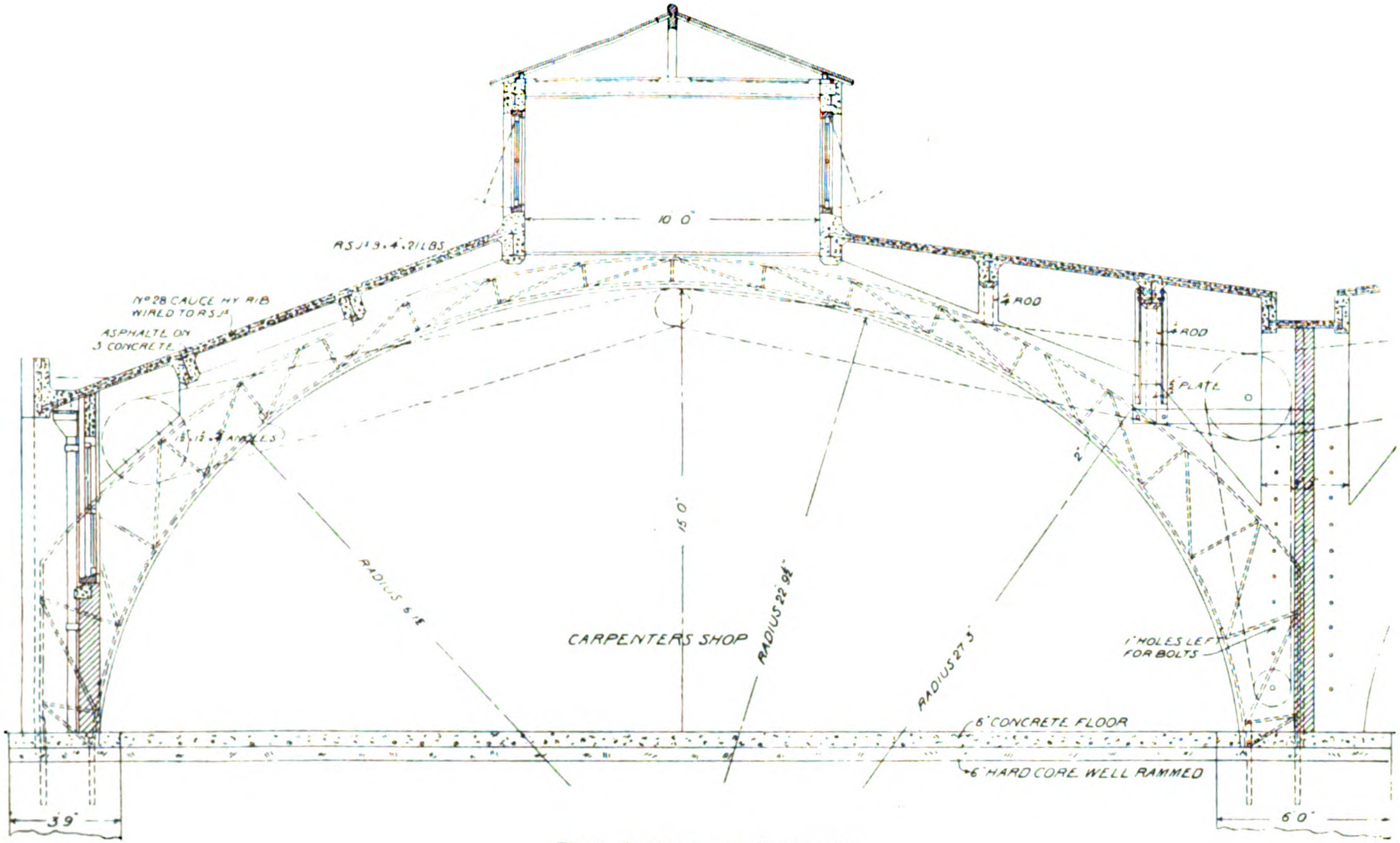


Fig. 4. **Section** showing Construction.
Borstal Institution, Borstal.

the chief constructional member consists of a large reinforced concrete arched beam, which is designed in such a manner that no outward thrust is exerted, but it springs direct from the foundations, and thus the reactions are vertical only. The foundations consist of large blocks of plain concrete 3 ft. 9 in. by 3 ft. under the outside ends and 6 ft. by 3 ft. under the centre division, and these are carried down to a solid foundation. The arches are 9 in. thick and they have a minimum depth at the crown of 15 in., this gradually increasing to about 3 ft. at the ends. The reinforcement is built up with angle sections in the upper and lower surfaces, with angles and flat steel bracing as indicated in the diagram No. 4 previously referred to, forming a light steel construction enveloped in the concrete as distinct from the usual type of reinforcement employed. The sloping roof above is carried by rolled steel joists placed about 5 ft. 9 in. apart and on the inner side of the two shops where it was necessary to keep the roof slab up in order to get the main line shaft at a sufficient height, they are supported by short reinforced concrete columns taken up from the back of the arch, as will be seen. The roof itself is formed with 3 in. of concrete reinforced with Hy-rib wired to the R.S.J.'s. A large lantern with glazed roof 10 ft. wide is formed above the central portion, with opening lights for efficient ventilation and light, in addition to the windows in the outside faces of the buildings. The floor of the carpenters' shop is constructed with 6 in. of plain concrete laid on hard core 6 in. thick, well rammed.

It will be seen that the effect of this construction is such that large open spaces occur over the arch and below the roof itself, and these allow the shafting, etc., for the machinery to be arranged at will and in such a manner that it is quite out of the way. The centering required a great deal of consideration, and this was designed by the surveyor with due regard to the maximum amount of efficiency and convenience. It could be moved forward as the work proceeded without dismantling the main members, while a good clear working space is given under the centre when in position. The only brickwork used consisted of that below the window sills in the outside walls and the 9-in. division wall between the two shops, and these are merely screens which have no real constructional value. The type of construction adopted is eminently suited to the circumstances of the case, and it is economical as compared with ordinary beams and columns, as the former would have necessarily been somewhat large on account of the span, and the arched beams are very rigid, considering the comparatively small amount of material with which they are formed.

OUR CONCRETE COTTAGE COMPETITION

In this issue we give some further Designs sent in.—ED.

SPECIFICATIONS TO THE DESIGNS

With Design No. 9. (By John Dall, 179 Gilmore Place, Edinburgh.)

Description of the Building.—The cottage has been designed mainly in concrete. The entrance to the building leads to a small entrance hall, which gives indirect access to a large living room, which is well lighted, is of good height, and roomy to a degree. Off the living room a larder has been shown with ample shelf accommodation, while in addition to this the space under the stair could be utilised for storage. The scullery or working kitchen is also of good size, and shows the spaces reserved for bath, copper, and sink ; while adjoining the sink a large cupboard is shown, also a place for coals. The back door gives indirect access to the scullery by a lobby, off which opens the w.c. All these apartments are well lighted The plans show the disposition of the various fittings, and the bath, when fitted up, would be a fixture, having a hinged table top for use when the bath is not required by the inmates. An easy stair leads to the bedroom floor, in which are situated three good-sized bedrooms. The front bedroom is of good size, and a hanging cupboard is arranged off this room. The two smaller rooms are of ample size and well lighted. The disposition of the beds is shown by dotted lines. It will be noticed that fireplaces are shown in every room, and these are all in the centre of the building, thereby ensuring a warm and comfortable house throughout.

The flooring of the living room and bedrooms would be of deal boards, the bedroom flooring being nailed to the breeze concrete, of which the floors, as well as the roof, would be constructed. The walls inside and the ceilings would be plastered in two-coat work. The only joinery finishing would be the doors and windows, so that the cottage is practically fireproof. Externally the building has been designed in the simplest possible manner. The aim of the author has been a square house, or as nearly so as possible, all the accommodation being arranged within the four walls, thus obviating the necessity of throwing out the usual projections for offices, etc., which are too common and ugly a feature of many houses of this class. The cottage has no useless or unsightly features, a good *line* of walls and roof being aimed at, and a well-defined central chimney stack and small front gable being sufficient to give the whole the necessary architectural balance.

The roofs would be covered with cement tiles, with cement ridges. The windows would be plain frames and sashes of white deal, as shown on the ½-in. detail. The doors would be white deal, framed and lined, with braces and plain facings, no mouldings of any sort being used anywhere in the building.

The author claims that every available inch of space in the plans has been successfully taken advantage of, and no space wasted in useless passages, etc., and the plans clearly show that a suitable house for a labouring man and his family can be designed, conveniently planned, and at the same time architecturally correct.

Specification of Concrete and the Method of its Application.

The "forms" for the walls to be constructed of 1½-in. thick planks with 4 in. by 2 in. uprights securely braced and placed at intervals about 6 ft. apart to withstand the pressure of ramming and tamping. All the timber used in the forms not to be cut to fit any particular length, but to be run beyond the work they enclose, as the timber may be used again and again in other work. The uprights to be securely braced, as required, with struts driven into the ground, and are to be 4-in. by 2-in. scantling.

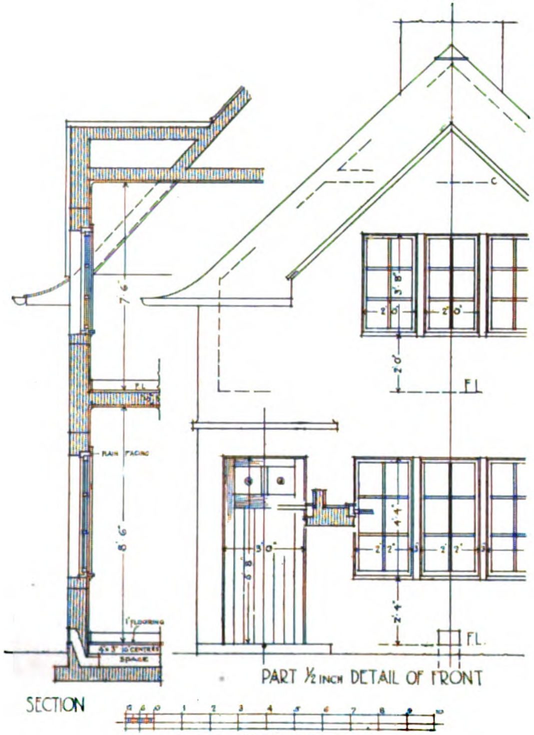
The concrete to be composed of 1 part best London Portland cement to weigh 90 lb. per cu. ft., 2½ parts of clean river or pit sand, free from anything in the nature of loam or dust, and 5 parts of hard clean broken stones, broken to a cubical form, and broken not larger than ¾ in. in diameter, great care being taken to see that no dirt of any description adheres to the coarse stuff.

The materials to be most thoroughly mixed together in order that they may have an extra texture. The constituents of the concrete to be gauged upon a level wooden platform, and turned over together twice with shovels while still in a dry state. The mixture to be turned over twice more while water is sprinkled upon it from a rose, care being taken to water it uniformly. The water used for admixture with the materials should be clean, free from acids, strong alkalis and organic impurities, 21 to 24 gals of water per cu. yd. of dry material being used for mixing.

Great care to be taken when laying the concrete, so that it comes in contact with the forms in every place, and the concrete to be shovelled into position and rammed until it is thoroughly consolidated.

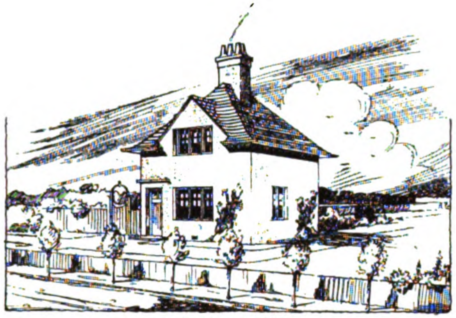
The walls to be carried up evenly all over the building to prevent vertical cracks where the newer

DESIGN FOR LABOURERS COTTAGE IN CONCRETE

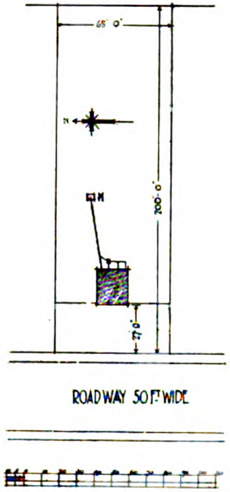


SECTION

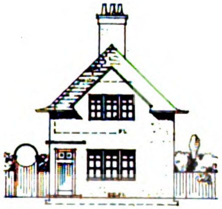
PART ½ INCH DETAIL OF FRONT



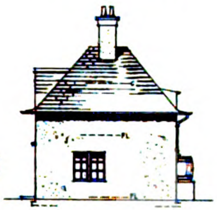
PERSPECTIVE VIEW



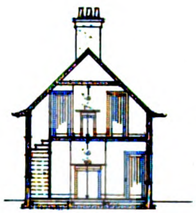
ROADWAY 50 FT WIDE



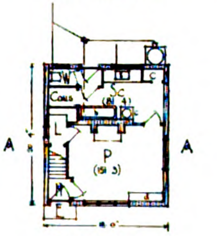
FRONT ELEVATION.



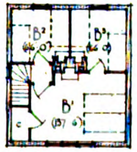
SIDE ELEVATION



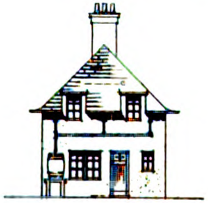
SECTION A.A.



GROUND FLOOR PLAN



FIRST FLOOR PLAN



BACK ELEVATION

SCALE FOR PLANS & ELEVATION

TABLE

M	3·9 × 3·0"	11 3" AREA	8 6 HEIGHT	95' 8" CUBICAL CONTENTS
P	13' 9 × 11' 0"	151' 3" ·	8· 6 ·	1285' 7" · ·
Sc	10' 6" × 7· 9	81 4 ·	8' 6" ·	691'· 4" · ·
B¹	13· 9" × 10· 0"	137· 6" ·	7· 6 TO CEILING	900' 0 · · ·
B²	8' 3" × 8· 0	66 0 ·	7· 6 · ·	400'· 6 · · ·
B³	8· 3" × 8 0	66· 0 ·	7 6" · ·	400'· 6" · ·
L	5 6" × 3· 6"	19· 3" ·	7' 6" HEIGHT	144'· 4" · ·
Coals	4 0" × 8 0"	17 0 ·	8· 6 ·	102' 0" · ·
C	3· 0" × 1 9"	5 3" ·	8' 6" ·	44 7" · ·
W	4 0" × 2· 6"	10 · 0" ·	8 6" ·	85 0" ·
Cᴹ FL	3·0" × 2 8"	13 4" ·	5· 6 ·	73' 4 · ·
				3,102' 0 TOTAL

CUBICAL CONTENTS
OF BUILDING
20·4" × 18·0" × 20·6"
= 7505 CUBIC FEET
AT 4ᴰ = £125·0·0·
MEASURED FROM BOTTOM OF
FOOTINGS TO HALF WAY
ABOVE BED Rᴍ CEILINGS
TO RIDGE

TABLE

Design No. 9 .. By John Dall.

work is joined to that already in position, and this to be done by laying the concrete in horizontal layers of from 8 in. to 9 in. deep.

After ramming, the upper surfaces to be roughened so as to bond more thoroughly with the first layers.

When the forms are removed from the walls a coating of whitewash or distemper may be applied to outer surfaces.

The internal partitions to be of coke breeze concrete blocks, 3 in. thick.

The roof to be of coke breeze concrete simply reinforced with metal meshwork.

List of Fittings and Cost of Each.

	£	s.	d.
1 Kitchen dresser of simple design	1	15	0
1 Kitchen range (Mushet's, Edinburgh, No. 2, light cottage range, complete)	2	10	0
3 Mantel shams (Mushet's) 19s. 6d. each	2	18	6
1 Simple range in scullery	1	10	0

Estimate of Cost.

In determining the cost of the building, the author, from former experience in structures of a similar character, determined the cost per cu. ft. of these, and applied the result to this particular case, with the following result :—

ft.	in.	Cubical contents			
18	0				
20	4	.. 7,503 ft. @ 4d.	£125	0	0
20	6				

(As shown in Table on the sheet of drawings.)

To check this figure the author carefully *took off the quantities in each trade*, priced the various items at current rates, with the following result (collected from Bill of Quantities)—viz. :—

	£	s.	d.
Concrete and Mason Work.			
Including concrete to walls, concrete chimney stack, cans, breeze concrete to floors, ceilings, and roofs, breeze concrete block partitions, concrete steps, concrete floors to back premises, concrete under living-room floor and use of sheathing for walls, ceilings, and roofs and excavations over site and in tracks, etc...	70	17	0
Joiner Work.			
Including living-room floor joists, flooring, skirting plate, windows, glass, doors complete, shelving, wood mantels, dresser, cupboards where shown and sundry small essentials	23	11	10
Plaster Work.			
Including two-coat work to all outer walls, inside, ceilings, and partitions	5	16	8
Plumber Work.			
Including lead flashings, eaves, gutters, rain-water down pipes bends, branches, etc., in connection, kitchen range and scullery range, and 3 bedroom interiors	10	2	4
Cement Slater Work.			
Including ridges and all slater's allowances for eaves, piends, etc.	11	0	7
Painter Work	3	10	0
TOTAL	£124	18	5

With Design No. 58. (By C. T. Mitchell, P.O. Box 3952, Johannesburg, South Africa.)

Description.—The building is detached, two storeys, each 8 ft. from floor to ceiling ; the upper storey being partly in the roof. The space under the low portion of the ceilings is occupied in all cases by the beds, thus giving all the clear floor space abundant head-room.

An infant's bed is intended to be placed in the large bedroom with the parents.

A fireplace is provided in one bedroom only, in case of illness.

The aspect of the house is arranged to give a maximum of sunshine in the parlour, kitchen, privacy to the front entrance, coolness to the larder, and a simple arrangement of drainage connections. The two back bedrooms get the morning sun and the front room the afternoon sun.

It has been assumed that the premises will only be accessible from the front road.

It is understood that the drawings submitted herewith form only a portion of what would be necessary for the erection of the building by a local builder. Complete details of all the reinforcement, etc., would be given together with a full specification.

Abridged Specification.

Foundation to be concrete 1 ft. 6 in. wide and 1 ft. 3 in. deep to 9-in. walls and 1-ft. arch and 9 in. deep to 4-in. walls.

Walls, concrete blocks in 1-ft. courses of varying lengths, 8½ in. thick externally and 4 in. internally, gathering over to flues in stock bricks at 28s. per 1,000.

Ground floor, 3 in. concrete *in situ*.

Roof, 3 in. concrete on Hy Rib " Pudlo " to be used in this concrete, finished with tar and sand applied hot. C.I. gutters and R.W. pipes.

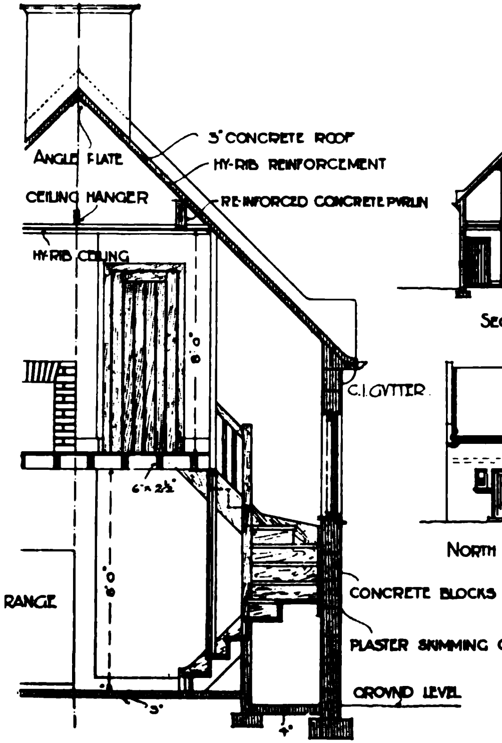
All walls plaster-skimmed inside and out, the laths finished with lime and oil distemper, internal walls finished with Hall's distemper.

Bedroom fireplace in red stocks.

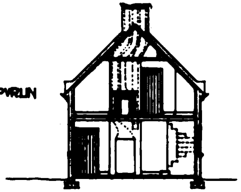
All windows to be side hung, casements in deal, with malleable cast-iron fittings.

CONCRETE COTTAGE COMPETITION

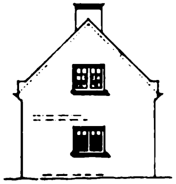
COST . 7950 CU FEET AT 3¾D - £125.



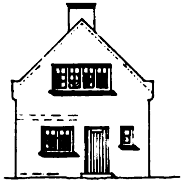
DETAIL SECTION CD



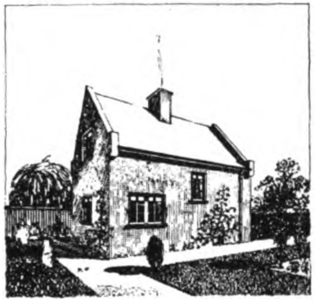
SECTION AB

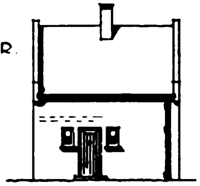


WEST ELEVATION

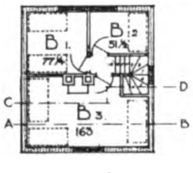


EAST ELEVATION

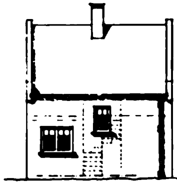




NORTH ELEVATION

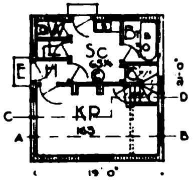


FIRST FLOOR PLAN

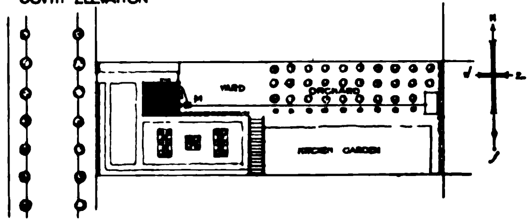


SOUTH ELEVATION

ROOM	DIMENSIONS	AREA	CONTENTS
HALL	4'6" × 3'3" × 8'0"	14¾	118
K. PARLOUR	17'6" × 10'0" × ″	163	1304
SCULLERY	9'0" × 7'3" × ″	65¼	522
BEDROOM, 1	9'0" × 8'7" × ″	77¼	618
″ 2	8'7" × 6'0" × ″	51½	412
″ 3	17'6" × 10'0" × ″	163	1232
BATHROOM	6'0" × 5'0" × ″	30	240
LARDER	4'6" × 2'6" × ″	11¼	90
WC	4'6" × 2'6" × ″	11¼	90
		SQ FEET	CU FEET



GROUND PLAN



BLOCK PLAN

SCALE 8 FEET TO 1 INCH

DESIGN NO. 58 ... BY C. T. MITCHELL.

All woodwork to be carbolineumed—two coats—window sills to be 6-in. by 6-in. red paving tiles. All doors to be 1½-in. framed and ledged.

First floor, 6-in. by 1-in. deal flooring on 6-in. by 2½-in. joists at 15-in. centres; all exposed on underside.

The concrete for the blocks to be made of five parts of clean boiler clinker, broken to pass a ½-in. sieve, the grit made in the process of breaking and 1 part of Portland cement. The blocks can be made on the site in varying lengths in ordinary plant trough forms, thus :

The overhang of the roof to be formed *in situ*, the foot of the Hy Rib, the tie bolts and the bolts for the C.I. gutter being placed in position first. The Hy Rib for the ceiling is secured to the hanger in the centre and shored under the forms for the reinforced concrete purlin, which is allowed to set before the Hy Rib for the roof is placed in position. The steel reinforcement for the purlins passes through the rib of the Hy Rib to support the ceiling.

The bedroom hearth is of similar concrete to above and 3 in. thick carried by ½-in. reinforcing rods bolted through the floor joists.

The ground floor to be troweled smooth and finished with neat cement and iron oxide.

List of Fittings.

Allowed for in price of £125.

American cooking stove, self-fixing, p.c. £3.
Canadian catches to all doors, @ 1s. 3d. each.
Locks to external doors, @ 2s. each.
Casement stays, 1s. 3d.
Codspur fasteners, 1s. 3d.

Not Allowed for.

	£	s.	d.
Bath	2	5	0
Sink	0	7	6
Copper	1	17	6
W.C., including wood seat	0	15	0
Cistern	0	9	6

Estimate of Cost.

Cubical Contents of Building.

Foundations—

```
ft  in.                           ft.  in.
41   0 }                          33   0 }
 1   6 } × 1 ft. 3 in.             1   6 } × 1 ft  3 in.
-------                           -------
66   0                            16   6
16   6                            33   0
-------                           -------
82   6                            49   6
-------                            1   3
                                  -------
                                  49   6
                                  12   4½
                                  -------
                                  61  10½
                                  -------
```

Main Building—

```
  ft.  in.
  19
  21
 -------
  19
  38
 -------
 399
  19   6
 -------
 199   6
3591
 399
 -------
7780   6
  82   6
  62   0
7925   0
 -------
  25   0 in chimney
 -------
7950   0
```

Cubic Feet.	Cost of Building in pence.	Price per cub. ft.
7950	30·000	3·75 × d.

The above estimate is made on the basis of 3¾d. per cub. ft., a figure decided on before commencing the plans and computed from a comparison of the intended method of construction with work already erected and briefly described on page 16 of the January issue of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

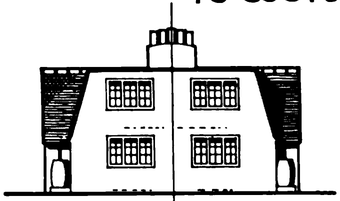
A priced bill of quantities, I find, gives an estimate within 1 per cent. of the above figures.

With Design No. 227. (By D. A. Beveridge, Prudential Buildings, 36 Dale Street, Liverpool.)

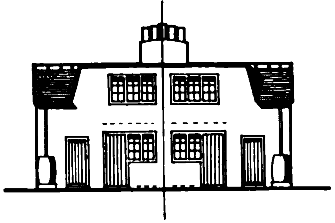
THE merits claimed for this design are as follows :—

1. All three bedrooms are on First Floor, thereby giving a better arrangement and saving considerably on the cubic contents of design, as the small bedroom is placed over w.c., coals and larder, all of which are about 6 ft. 3 in. floor to ceiling.

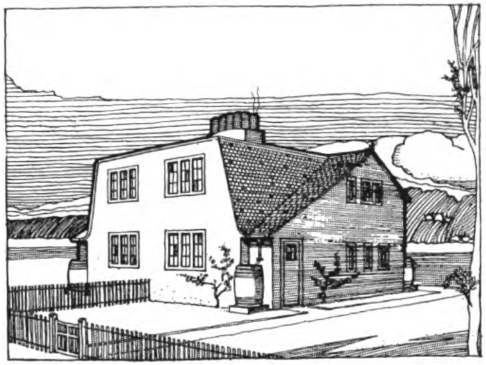
A PAIR OF CONCRETE COTTAGES
TO COST £125 EACH



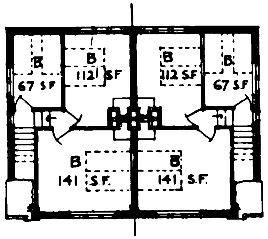
FRONT ELEVATION



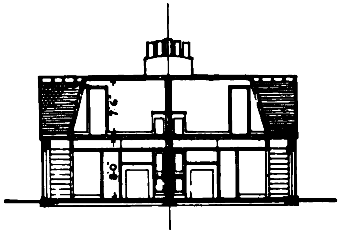
BACK ELEVATION



VIEW FROM ROAD



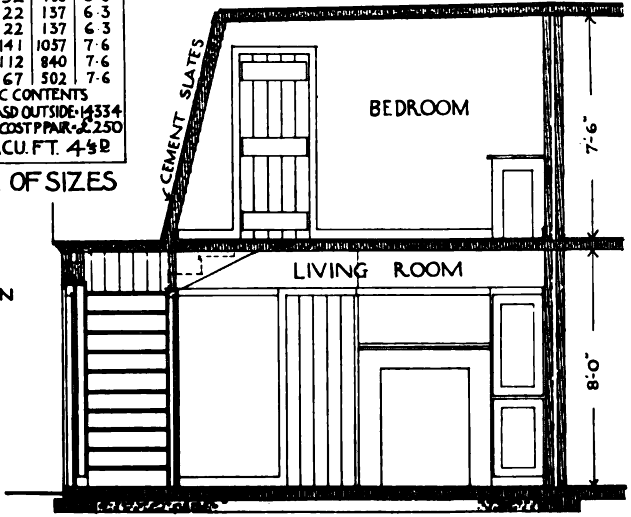
FIRST FLOOR



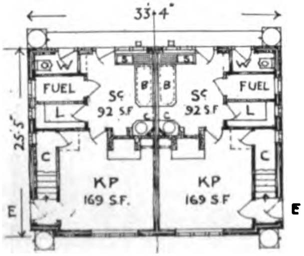
SECTION

	SIZES OF ROOMS	FLOOR AREAS	CUBIC CONTS.	HEIGHT
KP	13·6×12·7	169	1352	8·0
SC	10·2×8·10	92	736	8·0
F	6·8×3·4	22	137	6·3
L.	6·8×3·4	22	137	6·3
B.	12·7×11·3	141	1057	7·6
B	12·9×8·10	112	840	7·6
B.	10·2×6·8	67	502	7·6
TOTAL CUBIC CONTENTS OF PAIR MEASD OUTSIDE · 14334				
EST. TOTAL COST P PAIR · £250				
PRICE PER CU. FT. 4¼D				

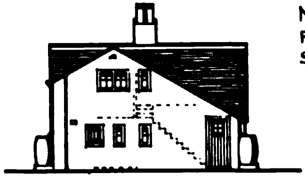
TABLE OF SIZES



HALF-INCH DETAIL

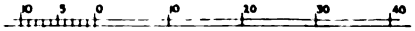


GROUND FLOOR



END ELEVATION

NOTE:
FOR BLOCK PLAN
SEE REPORT.



SCALE OF FEET

Design No. 27 By D. A. Beveridge.

2. Large coal and larder accommodation.
3. One chimney stack only required, and all fireplaces on inside walls.
4. Staircase lit by window.
5. Entrance door has no direct communication with living room.
6. All rooms of good size.
7. No winders in staircase.
8. Cement footpath at back.
9. Good appearance from roadway. Cement slates are used to a certain extent to give a more rustic effect, and walls lime-whited. Woodwork to be painted apple green.
10. External walls being hollow this will ensure a dry house
11. Pipe will be provided to carry hot water from copper to bath.

General Specification.

Foundations.—The vegetable soil to be stripped off to depth shown on half-inch detail.

Fill in under concrete floors with 5 in. of dry broken stones or hard clinkers.

The whole site to be covered with a slab of gravel concrete 4 in. thick (5 in. where floors are in cement). (For proportions see under " Materials.") Slab to be laid in one homogeneous mass with footings as shown for outside and party walls only. One inch of breeze concrete to be laid over floor to Living Rooms, so that the flooring boards may be nailed hard down to breeze surface when thoroughly dry. Floor of scullery and offices to be floated up in cement (2 of sand to 1 of cement). Damp-proof course to all walls to be of tar or other approved material.

External Walls.—These walls are of concrete cast blocks of two thicknesses with 2 in. space between, built with concrete ties across cavity at regular intervals. The outer face to be 4 in. thick, composed of gravel concrete (for proportions see under " Materials "). The inner face to be of breeze concrete blocks 3 in. thick. Walls to have two coats of limewhite.

Internal Walls.—All internal walls to be of breeze concrete blocks 3 in. thick. Fireplace jambs to be in concrete. Walls of living room and bedrooms to be skimmed over with a coat of lime putty gauged with plaster of Paris. Walls to have two coats of limewhite.

First Floor.—The first floor to be constructed of 5 in. of breeze concrete with No. 9 Clinton wire reinforcement embedded in same over living-room, and No. 10 over scullery, etc. Flooring boards to be used for centering to floors. Floor boards to be nailed hard down to breeze.

Flat Roof and Sloping Portions of Roof.—The flat roof to be of gravel concrete 3½ in. thick with ½ in. layer of breeze concrete on underside to give key and give dry surface for plaster skimming to ceiling. Flat to have 1 in. floating coat sloped to sides composed of 2 parts of sand to one of cement, mixed with a waterproofing composition such as " Pudlo." Sloping roofs to be 4 in. thick in breeze concrete. Cement slates to be nailed direct to breeze roofs.

Chimney Stack to be circled up in cement with plain red pots, well weathered in cement.

Materials.—The concrete for foundations 4 in. external cast blocks. Roof flat, stack footings to water butts, and 2 ft. 6 in. pathway at back to be of 5 parts of gravel graded from ¾ in. to 3/16 in., one of sharp pit-sand and one of cement (from the Associated Cement Manufacturers), well mixed together on a boarded platform without excess of water. Slated portions of roof, internal partitions, first floor, and 3 in. inner lining to external walls, etc., to be composed of 5 parts of coke breeze free from dust and organic impurities, and one part of cement, all mixed together as above.

Cement slates to be of an approved make.

External doors and windows to be in red deal, and to be kept as simple as possible. Windows to be built in as work proceeds. Interior woodwork to be in canary wood or red deal if price will admit. All external and internal woodwork gutters and down pipes, water butts, etc., to have three coats of paint to approval.

List of Fittings required per Cottage.
Items 1, 2 and 3 only included as per Conditions.

	£	s.	d.
3 ft. kitchen range	2	10	0
Scullery hob grate	1	0	0
2 bedroom grates	1	0	0
Copper	0	10	0
W.C., with cistern complete	1	10	0
Bath complete with lid	2	0	0
Sink	0	10	0
4 waterbutts	1	0	0

Cubic contents of design measured from bottom of footings to 1 ft. above flat roof and half the height of sloping portions.

	cu. ft.
Main Block.	
27 ft. 4 in. × 25 ft. 5 in. × 18 ft. 3 in.	12,685
Deduct Sloping end portions.	
25 ft. 5 in. × 8 ft. × 2 ft. 3 in.	457
	12,228
Gable ends.	
24 ft. 9 in. × 13 ft. × 3 ft.	1,930
Add roofs at sides.	
24 ft. 9 in. × 5 ft. 9 in. × 1 ft. 4 in.	176
14,334 cu. ft. @ 4⅕d. = £250	14,334

THE ECONOMICAL DESIGN OF REINFORCED CONCRETE T-BEAMS.

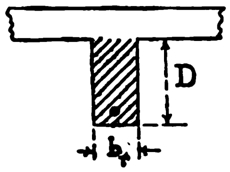
By J. B. GRIFFITH.

The question dealt with in this article is one of considerable importance to engineers and others, and, therefore, any contributions to this subject should be of interest to our readers.—ED.

IN finding the most economical section for a T-beam it is only necessary to consider the rib, or the portion below the slab. The reason of this is, of course, that, generally speaking, the slab is already designed by other considerations than the strength of the beam.

It will be found that the cost of the beam is a minimum when the cost of the steel is exactly equal to the cost of the concrete plus the cost of the formwork, and at the same time the width of the rib is as small as practicable.

This can be proved as follows :—



In a beam with any given "b_r"

Let x = cost of steel per ft. run,

x = cost of concrete plus formwork per ft. run,

and $2x$ = total cost of rib/ft. run.

If b_r is constant the cost of concrete plus formwork varies directly as the depth (the formwork to the soffit having been measured with the slab is not taken into account) and the cost of the steel will vary inversely as the lever arm. For our present purpose we will assume that the lever arm is equal to D. This is a close approximation, and the error is insufficient to affect the results appreciably. Therefore we can say that the cost of the steel varies inversely as D.

In the case assumed let the depth be increased to $D+e$; then the concrete and formwork cost will be increased to $\frac{x\,(D+e)}{D}$, and the cost of the steel will be reduced, in order to retain the same moment of resistance, to $\frac{x\,(D)}{D+e}$ and the total cost will now be

$$\frac{x(D+e)}{D}+\frac{x(D)}{D+e}$$

$$= 2x + \frac{xe^2}{D^2+De}$$

which is more than the original cost $2x$. Similarly, if the depth be reduced to $d-e$, the total cost will be

$$\frac{x(D-e)}{D}+\frac{xD}{D-e}=2x+\frac{xe^2}{D^2-De}$$

again more than the original cost. Thus we have proved that the conditions we assumed give the minimum cost for a given value of b_r.

As the width "b_r" is governed by other considerations besides the bending moment, it is not possible to eliminate "b_r" from any expression giving the economical depth of the beam in terms of the bending moment. But we can, by assuming unit prices for steel, formwork, and concrete, construct a formula giving this depth for each different "b_r".

In assuming the following values the writer is aware that they will not be applicable in every district, but for other prices the correct results can always be worked out in the same manner.

We will then adopt the following unit prices:

Concrete 27/- per cub. yd. = 12d. per cub. ft.

Formwork 2/3 per sq. yd. = 3d. per sq. ft.

Steel £14 per ton, fixed = 5·1d. per sq. in. per ft. run.

Then the concrete will cost per ft. run

$$\frac{b_rD}{144}\times 12\text{d.}=\frac{b_rD}{12}\text{ pence}$$

and the formwork $$\frac{2D}{12}\times 3\text{d.}=\frac{D}{2}\text{ pence}$$

and the steel $$\frac{B}{D\times 16000}\times 5{\cdot}1\text{ pence.}\quad (B=\text{bending moment in in.-lbs.})$$

As the cost of steel equals the cost of concrete plus the cost of formwork, we have

total cost per ft. run in pence $$=2\left(\frac{b_rD}{12}+\frac{D}{2}\right)=\frac{b_rD}{6}+D.$$

Also we have

$$\frac{5{\cdot}1B}{16000D}=\frac{b_rD}{12}+\frac{D}{2},$$

from which $$D=\sqrt{\frac{B}{261b_r+1566}}.$$

In the table at foot are given the values of "D" for different widths "b_r."

In the above b_r and D are in ins. and B is in in.-lbs.

If we assume in any case a value for b_r we can find D, and then find the necessary amount of steel approximately, thus

$$At=\frac{\frac{b_rD}{12}+\frac{D}{2}}{5{\cdot}1}={\cdot}0163b_rD+{\cdot}098D,$$

or else by the exact method and then check the assumed b_r and see whether it can be reduced.

Take a numerical example.

T-beam with 5 in. slab. Span 20 ft., freely supported. Load 60,000 lbs.

$B=1{,}800{,}000$ in.-lbs.

assuming $b_r = 10$ in.

$$D = \cdot 0155\sqrt{1800000} = 20\cdot 8 \text{ in.}$$

Cost per ft. run $= \frac{b_r D}{6} + D = 55\cdot 5$ pence.

Area of steel $\fallingdotseq \cdot 0163 b_r D + \cdot 098 D = 5\cdot 5$ sq. in.

To check these results, assuming that the centre of the steel is 3 in. above the soffit and the concrete is stressed at 600 lbs., the lever arm will be 20·87 in. and the area of steel

$$\frac{1800000}{16000 \times 20\cdot 87} = 5\cdot 4 \text{ sq. in.}$$

$$\left.\begin{array}{l}\text{Say, 2 bars } 1\tfrac{1}{4} \text{ in. dia.} \\ \quad\;\; 3 \;\;,, \;\; 1\tfrac{1}{8} \;\;\; ,,\end{array}\right\} = 5\cdot 45 \text{ sq. in.}$$

so that 10 in. is a suitable width of rib for accommodating the steel.

Checking the cost, we have

$$\begin{aligned}
&\text{Steel } 5\cdot 45 \text{ sq. in. at } 5\cdot 1 &&= 27\cdot 8 \\
&\text{Formwork } \frac{2 \times 20\cdot 8}{12} \times 3\text{d.} &&= 10\cdot 4 \\
&\text{Concrete } \frac{20\cdot 8 \times 10}{144} \times 12\text{d.} &&= \underline{17\cdot 4} \\
& &&\ \underline{55\cdot 6} \text{ pence.}
\end{aligned}$$

This result is practically identical with that found above. In practice we should probably have made the depth 21 in., and with a different thickness of slab the lever arm might be a little longer. Thus the results would not always agree quite so well, but in any case the method would give a very close approximation.

In buildings it often happens that, for the sake of appearance, it is necessary to make a number of beams similar in size although the spans and loadings may vary.

In such a case the cheapest total will be obtained by using the average B as the basis for the size of beam.

Take as an example

10 beams 20-ft. span, $B = 1{,}800{,}000$
5 „ 15-ft. „ $B = 1{,}000{,}000$
3 „ 10-ft. „ $B = 450{,}000$

we have
200 ft. at 1,800,000 = 360,000,000
75 ft. „ 1,000,000 = 75,000,000
30 ft. „ 450,000 = 13,500,000

305) 448,500,000

Average $B = 1{,}470{,}000$ in.-lbs.

The value of D should be worked out for this average moment, using a value for b_r which will suit the worst case.

For approximate estimating the average cost per ft. run could be arrived at on the same basis.

In the above example 10 in. will do for b_r and $D = \cdot 0155\sqrt{1{,}470{,}000} = 18\cdot 8$, say 19 in., and the average cost $= \frac{b_r D}{6} + D = 50\cdot 7$ pence/ft. run.

For estimating purposes this figure can be used and the exact amount of steel in each beam determined when the details come to be made.

We stated above that for the most economical beam "b_r" must be as small as possible. Let us check this statement. Thus in the example first taken assume that "b_r" is reduced to 8 in.

Then $D = \cdot 0165 \sqrt{B} = 22 \cdot 2$ in.

and the cost per ft. run is

$$\frac{b_r D}{6} + D = 49 \cdot 95 \text{d.}$$

showing a saving of 5½d. per ft. run on the previous section.

Another way of expressing this statement is to say that the deeper we make the beam the cheaper it will be so long as we can keep b_r small enough to satisfy our original condition that the concrete and shuttering cost as much exactly as the steel per ft. run.

This is shown to be general, as follows:

Assume a beam designed as above in which the cost $= \frac{b_r D}{6} + D$. Now increase D to $D+e$. The steel will be reduced to $\left(\frac{b_r D}{12} + \frac{D}{2}\right)\frac{D}{D+e}$, and to satisfy our conditions the concrete and shuttering will also cost

$$\left(\frac{b_r D}{12} + \frac{D}{2}\right)\frac{D}{D+e}$$

giving a total of

$$\left(\frac{b_r D}{6} + D\right)\frac{D}{D+e}$$

which must be less than originally because the fraction $\frac{D}{D+e}$ is less than one. Also b_r must have been reduced at the same time to maintain the relation of costs.

To prove that b_r must be reduced, let the new depth be denoted by D_n and the new width by b_n; the new total cost will be

$$\frac{b_n D_n}{6} + D_n$$

and we have seen above that this is less than

$$\frac{b_r D}{6} + D$$

and as D_n is larger than D, it follows that b_n must be smaller than b_r.

Thus we have

$$\frac{b_n D_n}{6} + D_n = \left(\frac{b_r D}{6} + D\right)\frac{D}{D_n},$$

from which

$$b_n = b_r \frac{D^2}{D_n^2} - 6 + \frac{6D^2}{D_n^2}$$

and, as D_n is greater than D, this expression is less than b_r.

In the foregoing examples b_r was assumed first, and after finding D and the amount of steel b_r was checked to see whether it could be reduced.

If, however, we can decide on a criterion for fixing b_r we can evolve a formula which will give its value direct instead of by trial.

Several considerations govern this value: for instance, sufficient width must be allowed to properly accommodate the bars; the beam must not be too narrow for the depth or there will be difficulties in construction; the width should also be sufficient to keep the shear stress within reasonable limits; in the case of continuous beams the compression over the supports sometimes governs it if it cannot be increased or the depth increased at those points. It will be found in nearly all cases, however, if b_r is decided by the shear that the other conditions will also be satisfied.

It remains to fix the limiting shear stress. It is, of course, possible to provide for the whole of the shear by reinforcements. At the same time it is considered by most designers good practice to so design the beam that the shear does not exceed a certain maximum on the concrete *neglecting the steel.* The reason of this is that sometimes, when the shear is high, cracks develop in the concrete even when there is sufficient steel to take the whole shear. In these cases the structure may not necessarily be in danger for the time being, but needless to say such cracks are to be avoided.

Many engineers fix this limiting value at 120 lbs. per sq. in.; others go as high as 200 lbs.

Adopting 120 lbs. to begin with, we have $120b_rD=S$ where $S=$ total end shear in lbs., or

$$D=\frac{S}{120b_r},$$

because we have assumed that D is approximately equal to the lever arm.

Substituting this value for d in our first formula, we have

$$\frac{S}{120b_r}=\sqrt{\frac{B}{261b_r+1566}}$$

from which

$$b='009\frac{S^2}{B}+\sqrt{'109\frac{S^2}{B}+\frac{'00008\,S^4}{B^2}}$$

or, more conveniently,

$$b_r='009\frac{S^2}{B}+\sqrt{'109\frac{S^2}{B}+\left('009\frac{S^2}{B}\right)^2}$$

For a limiting shear of 200 lbs./sq. in.

$$b='00326\frac{S^2}{B}+\sqrt{'039\frac{S^2}{B}+\left('00326\frac{S^2}{B}\right)^2}$$

We have now the means of determining quickly for **T**-beams

(1) The most economical section which

(2) at the same time limits the shear stress to 120 lbs. (or 200 lbs.) per sq. in.

(3) The cost per ft. run of beam.

The results are given in the summary.

SUMMARY.

For limit shear stress of 120 lbs./sq. in. neglecting steel

$$b_r = \cdot009\frac{S^2}{B} + \sqrt{\cdot109\frac{S^2}{B} + \left(\cdot009\frac{S^2}{B}\right)^2}$$

For limit shear stress of 200 lbs./sq. in. neglecting steel

$$b_r = \cdot00326\frac{S^2}{B} + \sqrt{\cdot039\frac{S^2}{B} + \left(\cdot00326\frac{S^2}{B}\right)^2}$$

Value of D

$$D = \sqrt{\frac{B}{261b_r + 1566}}$$

Values of D for different values of b_r

b_r	D
4"	$\cdot0195\sqrt{B}$
5	$\cdot0187\sqrt{B}$
6	$\cdot0178\sqrt{B}$
7	$\cdot0172\sqrt{B}$
8	$\cdot0165\sqrt{B}$
9	$\cdot0160\sqrt{B}$
10	$\cdot0155\sqrt{B}$
11	$\cdot0150\sqrt{B}$
12	$\cdot0146\sqrt{B}$
13	$\cdot0142\sqrt{B}$
14	$\cdot0138\sqrt{B}$
15	$\cdot0135\sqrt{B}$
16	$\cdot0132\sqrt{B}$
17	$\cdot0129\sqrt{B}$
18	$\cdot0126\sqrt{B}$

B = bending moment in in.-lbs.
S = total end shear in lbs.
D = depth of beam below slab in inches.
b_r = width of rib in inches.

Cost per ft. run of beam in pence =

$$\frac{b_rD}{6} + D$$

Area of tension steel:

$$A_t = \cdot0163b_rD + \cdot098D.$$

Basis prices:
Concrete 27/- per cub. yd.
Formwork 2/3 „ sq. „
Steel £14 per ton, fixed.

RURAL HOUSING.

We give below some particulars of some cottages actually erected, which show that it is possible to build cottages in concrete at £125 per cottage or £250 the pair.—ED.

THE question of rural housing has been so much discussed that it will doubtless be of interest to many of our readers to read a short description of some experimental work which has been carried out by a large industrial firm.

Messrs. Cubitt, of Gray's Inn Road, were requested to ascertain, from actual experiment, at what cost a pair of working men's cottages could be built, where all the resources of a large firm were concentrated upon its solution.

The result of their work is interesting and most instructive, and undoubtedly a real step forward has been made.

Cottage building has mostly been in the hands of the small builder, and for obvious reasons. The single cottage, or the pair of cottages, present so small a total of expenditure, that the ordinary percentage of builders' profit is a quite inadequate return to the large firm.

Inadequate, unless by means of standardisation, the employment of new methods, and the use of cheaper materials, first cost can be brought down. It is in the reduction of first cost that the work here described is so remarkably successful.

The elementary conditions of the problem are :—

1. The cottage must have adequate accommodation.

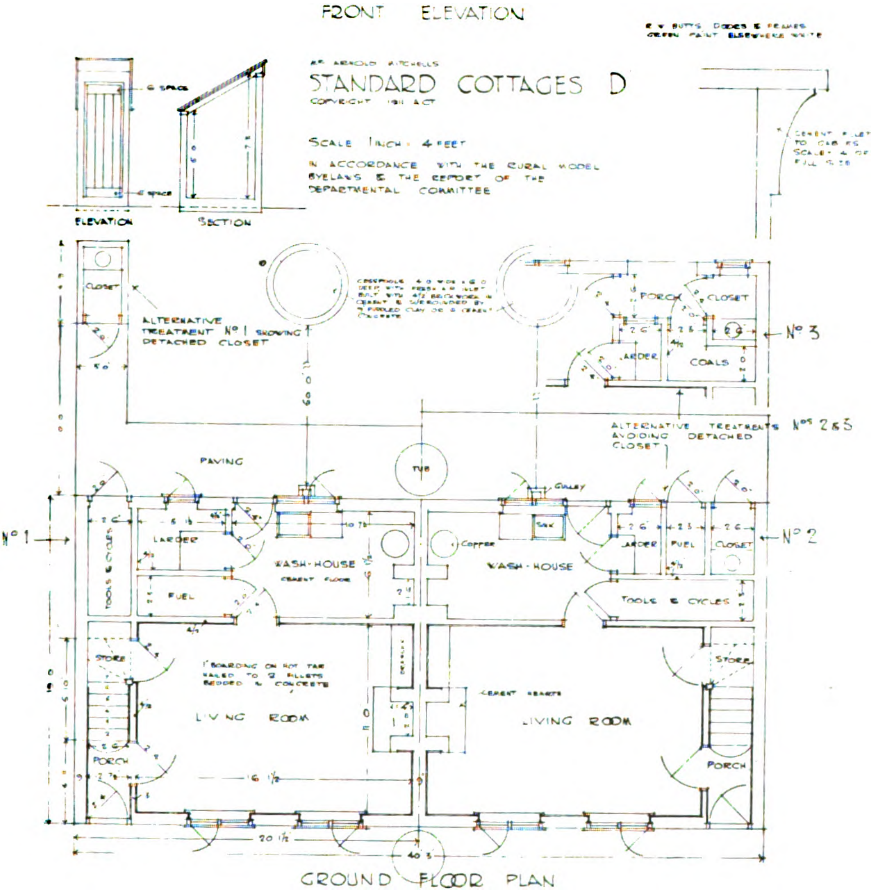
The standard of accommodation in a labourer's cottage is not a fixed thing, but for the purposes of this experiment the schedule provided in the Departmental Committee's report—the Committee of which Mr. Christopher Turnor was chairman—was adopted as one generally acceptable.

2. The cottage must conform to the medical officer's view of what is right and necessary for a healthy habitation.

3. The cottage must comply with the regulations of the local authority. For the purposes of this experiment the London Building Act of the London County Council, and the model building by-laws of the Local Government Board for rural districts, are, together, the standard adopted.

The whole matter was placed in the hands of Mr. Arnold Mitchell, whose experience in cottage work, loyal co-operation and initiative, ensured success, if success was possible.

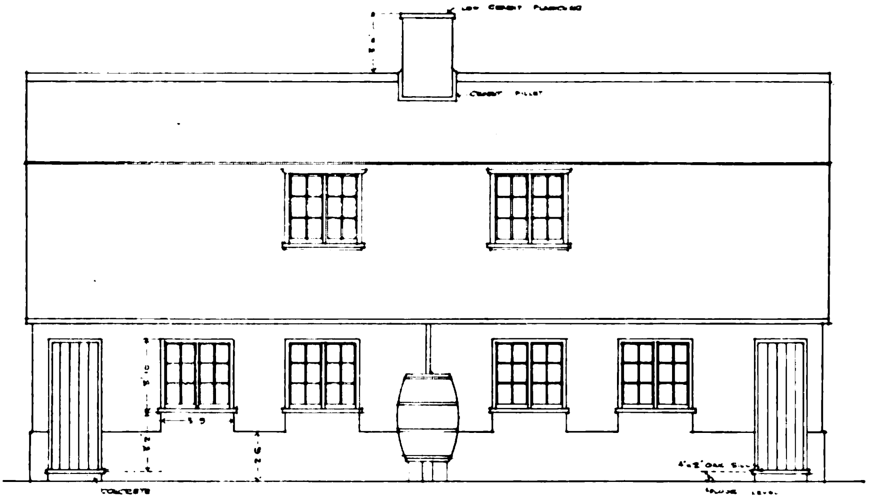
To the conditions imposed upon him Mr. Mitchell added a fourth, viz., that—as in all new cottages he is concerned with—all three bedrooms must be upon an upper floor. It is often economical to put one of the bedrooms upon the ground level; where, however, this is done the room is seldom, if ever, used as a bedroom. Mr. Christopher Turnor is emphatic upon the need for this proper distribution of the rooms.


FRONT ELEVATION
MR ARNOLD MITCHELL'S
STANDARD COTTAGES D
COPYRIGHT 1911 ACT
SCALE 1 INCH = 4 FEET
IN ACCORDANCE WITH THE RURAL MODEL BYELAWS & THE REPORT OF THE DEPARTMENTAL COMMITTEE
ELEVATION
SECTION
6 space
6 space
CLOSET
ALTERNATIVE TREATMENT No 1 SHOWING DETACHED CLOSET
5 0
CESSPOOL 4 0 WIDE & 6 0 DEEP WITH FRESH AIR INLET BUILT WITH 4½ BRICKWORK IN CEMENT & SURROUNDED BY 9 PUDDLED CLAY OR 6 CEMENT CONCRETE
PORCH
CLOSET
LARDER
COALS
No 3
ALTERNATIVE TREATMENTS Nos 2 & 3 AVOIDING DETACHED CLOSET
PAVING
TUB
GULLEY
No 1
No 2
2 6
2 3
LARDER
FUEL
CLOSET
TOOLS & CYCLES
WASH-HOUSE
CEMENT FLOOR
COPPER
SINK
STORE
1" BOARDING ON HOT TAR NAILED TO 2" FILLETS BEDDED IN CONCRETE
CEMENT HEARTH
DRESSER
LIVING ROOM
LIVING ROOM
PORCH
PORCH
STORE
16 ½
20 ½
40 3
GROUND FLOOR PLAN

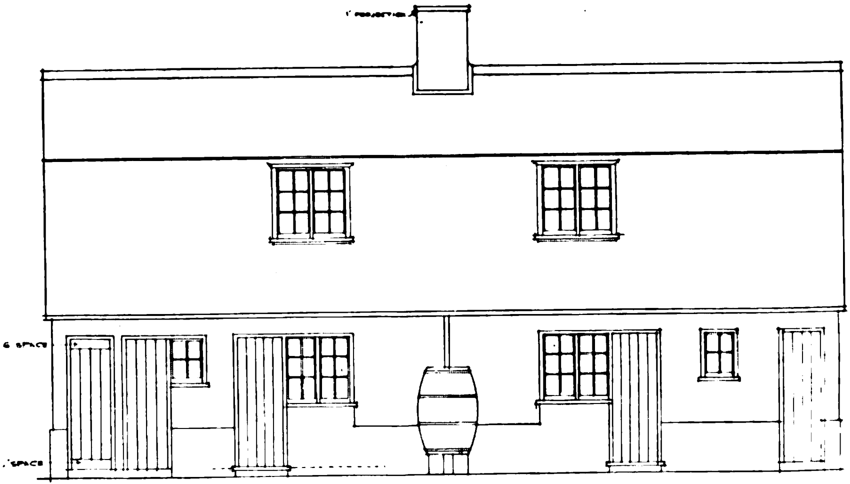
Each of the cottages built comprises an excellent living room, 165 sq. ft. in area, with good cooking range, a dresser, and with boarded floor; a 65 ft. sq. washhouse, with hob stove, copper, and sink; a good larder, fuel store, and detached closet—these all upon the ground floor. An entrance lobby is provided and a good well-lit staircase leading up to three bedrooms upon the upper floor. The largest bedroom has an area of 144 sq. ft. and has a good fireplace, and the smaller one each with 65 ft. sq. A paved area in the rear of the cottage is included covering 100 sq. ft. in area, and, in addition, there is a good shed, available as wood store, tool house, or bicycle shed.

This pair of cottages has been actually built for £250 the pair.

Where a larger number is erected in one place, and at one time, the cost might work out slightly lower, but any considerable reduction is hardly possible.



FRONT ELEVATION



BACK ELEVATION

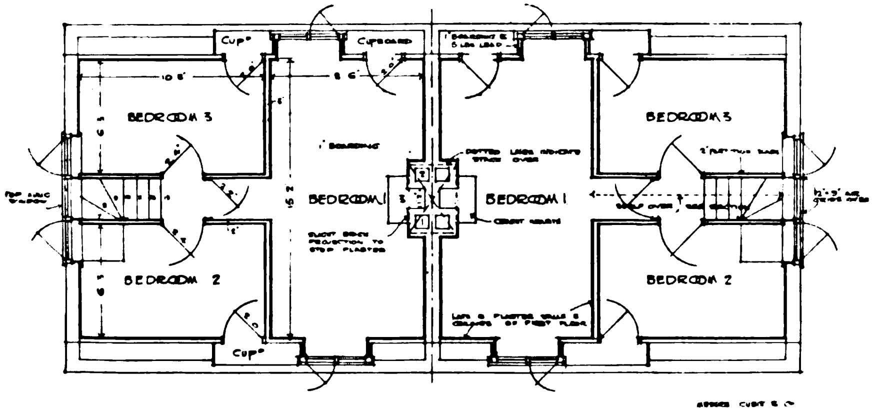
To this amount must be added what is necessary for the builder's establishment charges and his profit.

In the construction Portland cement has been mainly used.

The whole of the walling is carried out in Portland cement concrete, and the whole of the roof covering is carried out in Portland cement tiling. The structure throughout, excepting only the timber work to roof and upper floor, is made with Portland cement ; and it is this thorough substitution of Portland cement for the more usual building materials which has gone a long way to achieve the result.

In adopting this material, its limitations were also recognised. It was borne in mind that the very excellence of its qualities had often been the source of its undoing where used in cottage building. An ordinary cement concrete wall is so close and homogeneous in its structure, so impervious in its nature, as to present a condensing wall surface quite unfitted for habitable rooms. Cottage walling, to be good walling, must be of less unyielding material ; a material which absorbs the moisture in the atmosphere, instead of condensing it upon its surface.

To this end hollow concrete blocks were employed, and these hollow blocks were made of ash, or cinder, in place of the hard material commonly used.

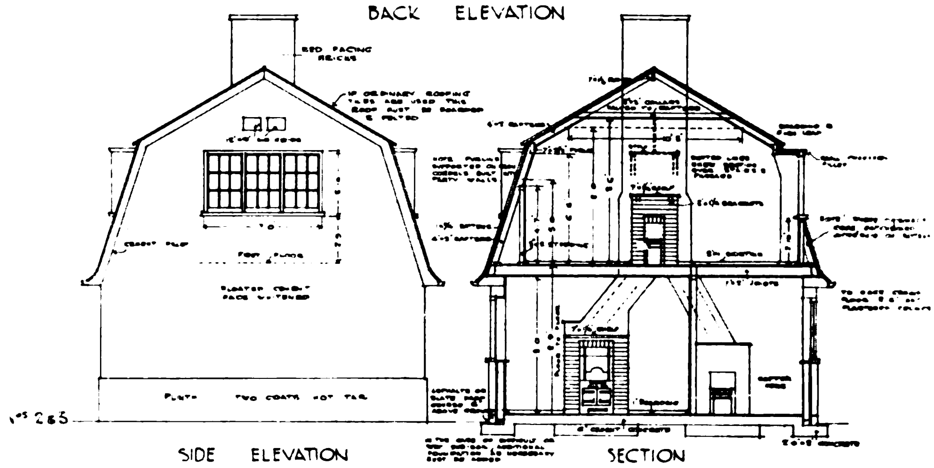


FIRST FLOOR PLAN

Provided combustion had been perfect and no sulphur remained in the ash, the refuse from the dust-destructor made an ideal matrix for this purpose ; the blocks would be light, and they would be porous ; the material was exceedingly cheap ; and so the strange sight was seen of refuse being delivered on to the site, and an American concrete-block-making machine at work turning out the most excellent building material.

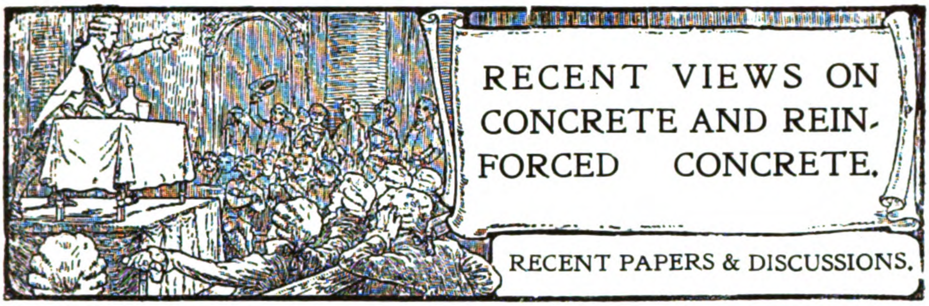
On another portion of the site a tile-making machine was turning out eighteen large red roofing tiles per hour made of cement and sand. Ashes are no good for tile manufacture. It is just as important to have the roof covering non-absorbent and damp-proof as it is to have the internal walling porous and absorbent. The hollow concrete blocks are rendered externally with cement and sand, and they make a good key for the plastering inside. Where no plastering is required the walling blocks are finished in the machine with a smooth face, and built up ready in the wall for whitening without further labour. All this makes for cheapness, whilst for strength and durability there is no doubt whatever the advantage is upon the side of the cement over other material.

The same economical care exercised in the structure was extended to other portions of the building. The cheapest scantlings of timber were employed; a reduction of something like fifty per cent. was secured on the joinery cost—this by putting the contract out to joinery mills who specialise upon this class of work. Special prices, upon the security of large orders, were secured for the ranges, for the grates, and for the ironmongery—prices which will be available to all who apply for them.



In addition, we publish complete plans. These are sufficiently detailed to speak for themselves.

The above work was carried out by Messrs. Cubitt, at the request of the Associated Portland Cement Manufacturers, Ltd.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

RECENT PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE AMERICAN SOCIETY FOR TESTING MATERIALS.

TESTING CONCRETE AGGREGATES.

By CLOYD M. CHAPMAN.

At the recent meeting of the above Society some very interesting Papers were presented in the section devoted to Concrete, and below we present one of them by Mr. Cloyd M. Chapman. We hope also to present extracts from other papers in future numbers.

So much has been said and so little progress made in the matter of testing concrete aggregates, that the concrete industry finds itself at the present time in a peculiar position. It is using vast quantities of materials, which are agreed upon to be extremely variable and therefore very much in need of testing, and yet it is without any recognised standard method of testing or of interpreting results of tests.

Many concrete engineers appreciate the necessity of testing the sand and stone as well as the cement to be used in concrete. There are fairly definitely prescribed standard methods for the testing of cement, but the testing of the sand and stone is left largely to the individual preference of the engineer. The result is that while many engineers test these materials, they do so according to their own ideas. As a result, there are now in use about the same number of methods of testing sand and stone as there are laboratories engaged in the work.

In the matter of testing, sand seems to have received a great deal more attention than the coarse aggregates. This may be, and probably is, due to the fact that more troubles with concrete have been charged against the fine aggregate than against the coarse aggregate. This is perhaps quite true, but there is no doubt that the strength of a concrete is due in a considerable measure to the coarse material used. Mixed with the same cement and sand in the same proportions, some stones will give much stronger concrete than others. For the strongest reinforced work it is important that a quality of stone be used that will make the best concrete.

Experiments made in the laboratory of Westinghouse, Church, Kerr and Co. indicate that one stone may produce concrete from 50 to 100 per cent. stronger with the same proportions of the same sand and cement than another stone

If both of these stones were available for the same job, and if the work at hand were one requiring concrete of maximum compressive strength, there is no question as to which ought to be used. There should, however, be some standard method adopted for determining the relative value of the available materials for any important piece of concrete work.

It is not an easy matter to decide just what tests shall be applied to stone. Hardness, density, weight per cubic foot, and percentage of voids may in some cases have a bearing on quality, but they do not serve to enable one to choose the stone which will make the strongest concrete. For instance, the strongest concrete made in the series of tests above referred to was made from a light porous material, having a comparatively low compressive strength and a high percentage of voids. The making up of concrete compression test specimens of the cement, sand and stone in varying proportions is a very commendable practice, but the results are functions of so many variables that it is quite impossible to determine from them the specific effect of the coarse aggregate used on the strengh of the specimen.

In an effort made in the laboratory of Westinghouse, Church, Kerr and Co. to develop some more useful form of test for coarse aggregates, there was tried, among others, the method proposed in this paper, which seems worthy of further investigation and development by those most interested.

The author's method in its present form consists in determining the compressive strength of a specimen made up of what may be called a skeleton structure of the material under investigation, the interstices of which structure have been filled in with a standardised neat cement or a cement-sand grout, in a sufficiently fluid state to flow into and fill all the voids.

The pieces of stone are in close contact with one another, and if held in place by a binder to prevent the slipping of one stone upon another, the total compressive strength of the skeleton framework might be readily determined. It is the purpose of the standard grout to furnish the binder to hold the stones in place for crushing.

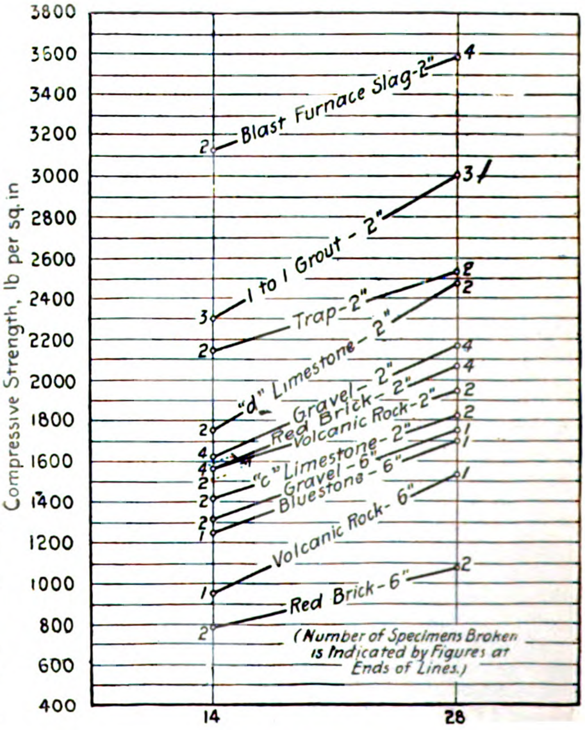
The resulting compressive strength is a function of many variables, yet probably of a less number than if the stone and grout were mixed together to make a concrete before being placed in the mould.

The details of manipulation are as follows. The moulds used are 6-in. cylinders, 6 in. high, and 2-in. cubes. The size of stone used is ¾ to 1¼ in. (averaging about 1 in.) for the 6-in. specimens, and ¼ to ½ in. for the 2-in. specimens. Sufficient stone to fill the mould is soaked in water for 24 hours to saturate it so that water will not be absorbed from the grout.

Sufficient grout is made up of a mixture of equal parts by weight of Portland cement and a good grade of sand, screened through a 20-mesh sieve, with about 35 per cent. of water added, for the 6-in. cylindrical specimens, and of neat cement with about 45 per cent. of water added for the 2-in. cubes.

The wet stones are mixed in with the grout until they are thoroughly coated. The mixed stone and grout are poured on a ¼-in. sieve and the surplus grout allowed to drain off. The stones, coated with grout, are placed in the mould and are packed down well, shaken while being put in place, so that they are in close contact with one another.

The remainder of the grout is well stirred up and poured into the mould near



(Number of Specimens Broken is Indicated by Figures at Ends of Lines.)

Age of Specimen, Days.

Compressive Strength of 1:2:5 Concrete in the Form of 2-in. Cubes and 6-in. Cylinders.

one side, jarring the mould continually so that all the voids between stones will be filled. The top of the specimen is finished smooth by adding grout and by slight troweling after the cement has begun to harden a little.

The 6-in. specimens are stored in a damp closet until broken at the ages of 14 and 28 days, while the 2-in. cubes are stored in water. The specimens are faced with a thin layer of plaster of Paris a few hours before crushing.

The results obtained are shown graphically in the accompanying diagram.

It may be noted that the several stones tested ranged over quite wide limits. The points plotted represent averages of from 1 to 4 specimens.

It is greatly regretted that there are not many more specimens of the 6-in. size. There are others under way, but at the time of writing the specimens have not been broken.

It is hoped that this method, together with any others which are considered promising, may be thoroughly investigated by a properly constituted committee of the Society, and by individuals and institutions sufficiently interested, in order that we may have at no very distant date a standard method of testing these materials.

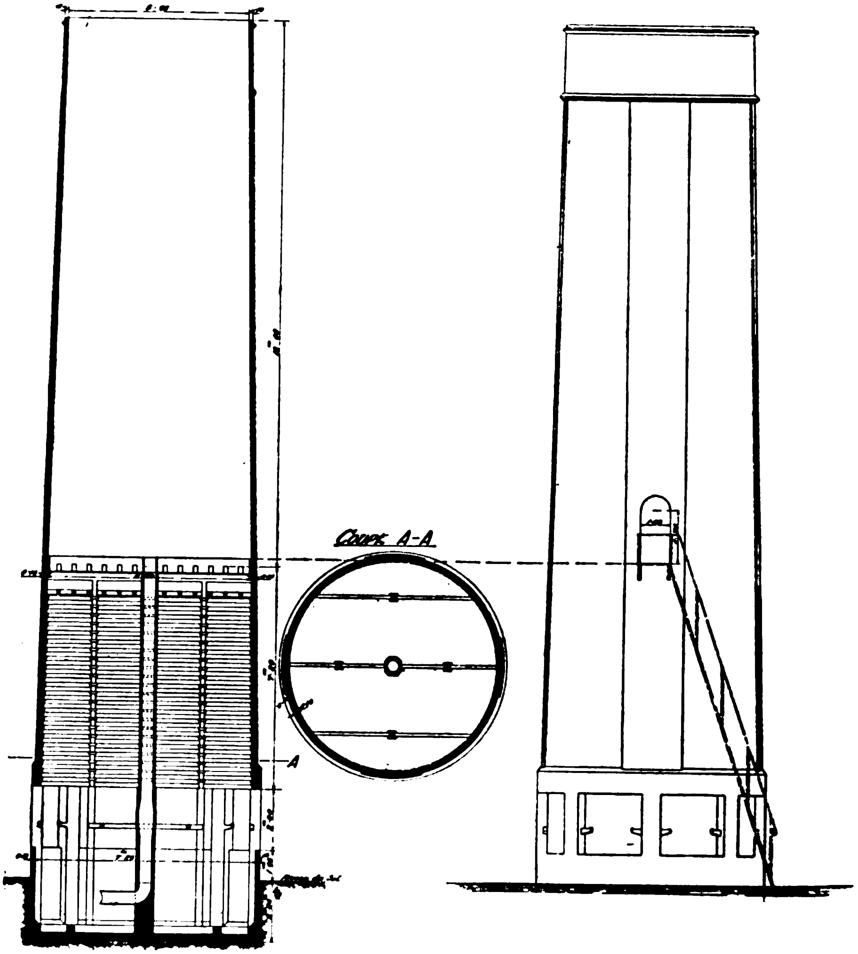
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE COOLING TOWER.

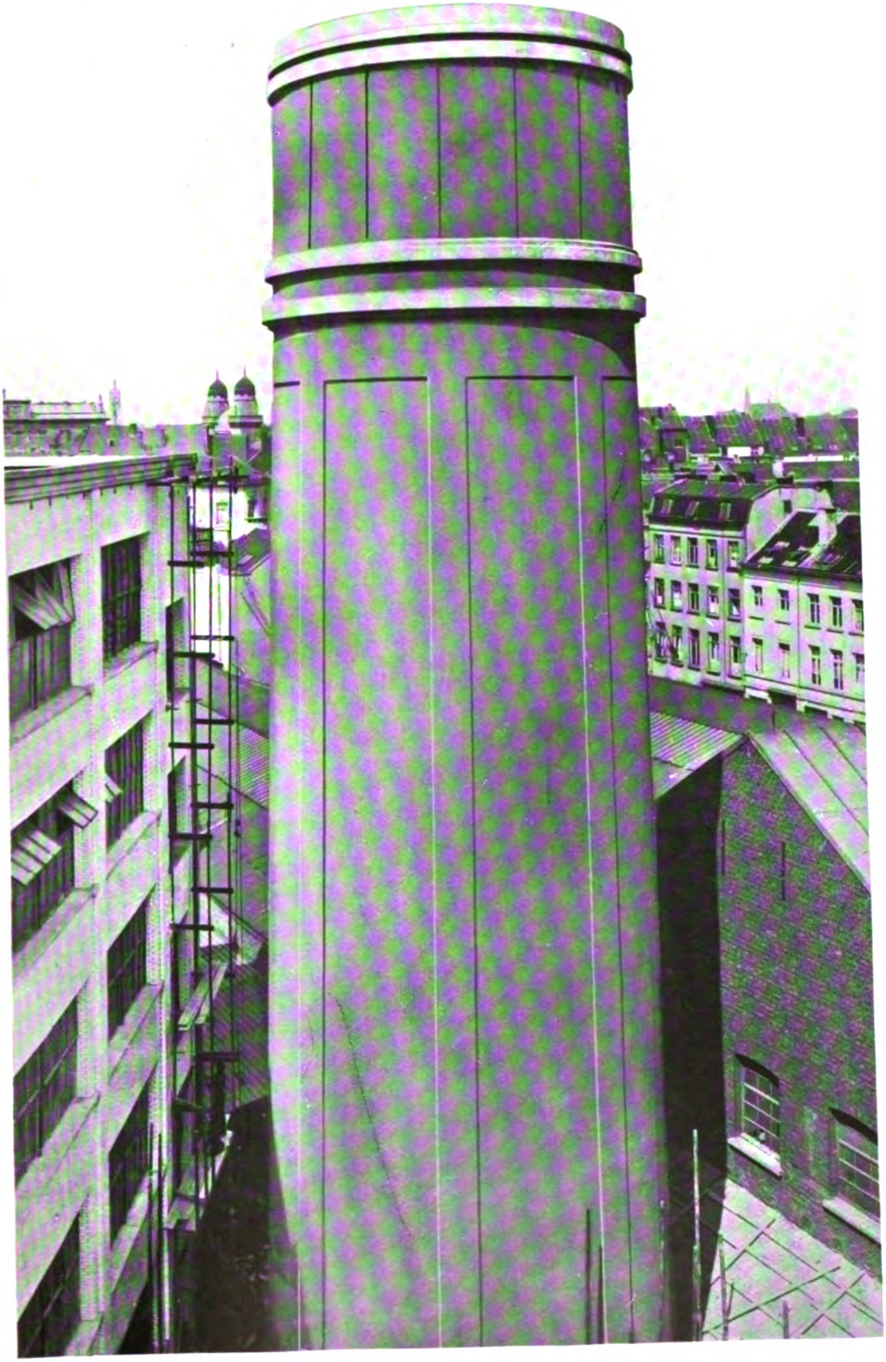
Reinforced concrete has now been applied for the erection of a large water cooling tower at Antwerp for the Bell Telephone Manufacturing Co., and the accompanying illustration shows the general aspect of the completed tower, which has been designed on the Coignet system of reinforced concrete.



Section. Elevation.

Reinforced Concrete Cooling Tower.

The surrounding buildings, of which we gave a description in one of our previous numbers, are entirely constructed of reinforced concrete on the same system.



View of Finished Structure.
REINFORCED CONCRETE COOLING TOWER.

Owing to the lack of space the company decided to erect a circular water cooling tower instead of a large rectangular cooling tower, which would have required more space than was available.

Various schemes were considered in steel work, which is the usual material adopted for circular water cooling towers. Preference, however, was given to reinforced concrete, on account of the greater economy of this material in initial cost and in maintenance.

It is shown in the drawing herewith reproduced that the body of the tower is composed of a reinforced concrete cylinder, having a thickness of 12-14 centimetres (about 5 in.), the total height of the tower from the level of the ground being 28·29 metres (about 92 ft.). The internal diameter varies between 7·00 metres to 5·95 metres (about 20 ft.).

The cooling apparatus, which is situated at the lower portion of the tower, is also constructed in reinforced concrete, and in accordance with the Hamon system. This method consists of an arrangement of small reinforced concrete battens, upon which the water drips from distributing tanks.

The lower portion of the tower forms a reservoir to collect the refrigerated water, and the lateral openings are meant to provide an air intake to form a draught up the tower.

The cooling arrangement has been calculated for a cooling capacity of 400 cubic metres per hour from 32·2° C. to 24° C., with dry bulb of 15° C., and 45 per cent. humidity.

The brackets projecting from the openings are meant to support reinforced concrete baffles, to direct a current of air up the tower; and the hot water is forced up a vertical central pipe, leading into the various distributing channels.

The reinforcement is composed of round bars of mild steel, and "Ceresit" was mixed with the concrete in order to render it absolutely waterproof.

The entire work was carried out in accordance with the requirements, and under the general superintendence of Mr. G. A. Pennock, Engineer of the Bell Telephone Manufacturing Co.

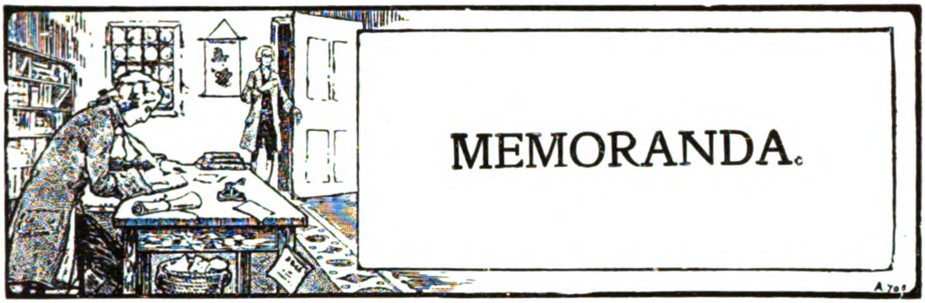
The working drawings were prepared by Messrs. Edmond Coignet, Ltd., 20, Victoria Street, Westminster, and the work was executed by Messrs. Hargot and Somers, of Antwerp.

THE ARCHITECTURAL POSSIBILITIES OF CONCRETE.

ENLARGEMENT OF RAILWAY STATION AT KUALA LUMPUR, MALAY STATES.

We have at different times shown in this journal that concrete from the architectural point of view has many possibilities, and we would refer our readers to an article which appeared as recently as April of this year on this subject.

Our Frontispiece is another good example to hand, and shows a railway station at Kuala Lumpur, the capital of the Federated Malay States. This station has recently been enlarged.



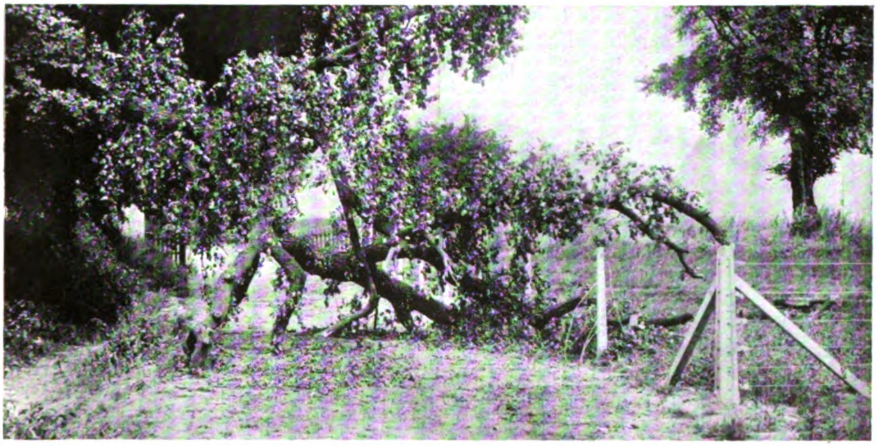
MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

City and Guilds of London Institute.—We have received the programme for the 1914-15 Session of the Department of Technology of the above Institute. As usual, the programme and syllabus for the various examinations have been well and carefully drawn up, and practically every question appertaining to technological subjects and also manual training and domestic subjects finds a place in the students' curriculum. The examinations are held at varying dates as will be seen from the calendar. Under the Section "Structural Engineering" we note the question of reinforced concrete forms part of the examination syllabus, both under Grade I. and under the Final Examination. At the end of the book will also be found a list of registered teachers qualified for giving instruction in Technology. Copies of the programme may be obtained from any bookseller (price 9d., postage extra). Communications regarding recognition or registration of schools or classes, examinations, etc., should be addressed to the Superintendent of the Institute, at Exhibition Road, London, S.W.

Concrete Fence Posts.—A striking illustration of the strength and stability of concrete fence posts is shown in the accompanying photograph.

During the recent storms a large elm tree on a farm of the Associated Portland Cement Manufacturers, at Aylesford, Kent, was blown down and fell across the fencing. All the wires were snapped, but the posts withstood the strain without showing the slightest sign of damage. Some parts of the tree had been cleared before the photograph was taken, or it would have been seen that several heavy boughs fell on to the posts as well as across the wires; but in spite of this, all the posts remained rigid in their positions and the fence was repaired by simply re-wiring the posts.



The posts are 6 ft. long by 5 in. square at the bottom, tapering to $4\frac{1}{4}$ in. at ground level and $2\frac{1}{2}$ in. square at top. They carried six wires each of seven strands of 16-gauge galvanised iron wire.

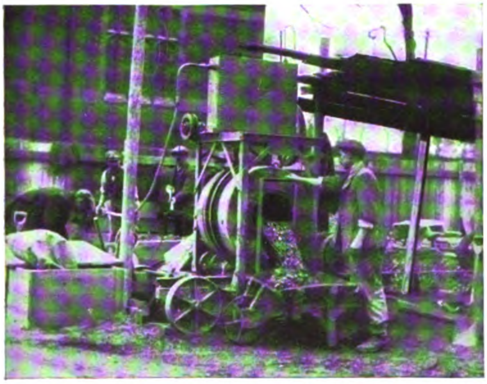
The Use of Concrete on Railways.—At the recent Congress of the Permanent Way Institution in Paris visitors were shown many novelties in connection with French railway work, and what seemed to impress them most was the extensive use made of reinforced concrete by engineers in France.

At some goods yards in Bercy reinforced concrete troughing was found to be in use as troughing for all pipes and wires to and from the signal cabins. The goods sheds themselves were generally built of reinforced concrete. A locomotive shed at Crepy-en-Valois was found to be of much interest, and on this building even the smoke cowls were built of the same material and were generally admitted to be superior to the wooden ones used in this country. Further on the road to Ermont the visitors inspected a new station built entirely in concrete, special interest being displayed in a long-span reinforced concrete footbridge. At Ermont the Nord Railway has very important workshops, and here the material was shown in use for signal wire posts, fence posts, rod boxes and covers.

TRADE NOTICES.

Edmond Coignet and Co., Ltd.—We are requested to state that in spite of the fact that several of the French and English members of the engineering staff of this firm have been called away on account of the war, they are carrying on business as usual. At present they are dealing with a large number of very important contracts such as the designing of some forty warehouses and sheds for the new docks of Buenos Aires, the new Science Museum for H.M. Office of Works, the new Epsom Asylum, extensive coal bunkers and elevated railroad for the London County Council at Crossness, etc.

The Bengal Artificial Stone Co., Ltd.—This company have issued a small pamphlet on the selection of aggregates for cement concrete works, and in it they point to the absolute need of a good sound aggregate. Quotations are given from reports and papers. Some of the buildings in India to which their artificial stone has been applied include the Medical College, Calcutta; Government Press Buildings, Dacca; Government House, Chittagong, etc. The firm are doing good work in India in pressing forward the claims and advantages for reinforced concrete and concrete work for buildings, etc., and they appear to have gained the confidence of the India Government railways and mercantile community. They certainly are adopting the right course by the use of crushed granite as their aggregate instead of slags and similar material, which owing to the sulphur contained in them set up a chemical action which is detrimental to all cement concrete works. Further particulars of their products may be obtained on application to the Bengal Artificial Stone Co., Basco House, Entally, India.



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VICTORIA
CONCRETE MIXER

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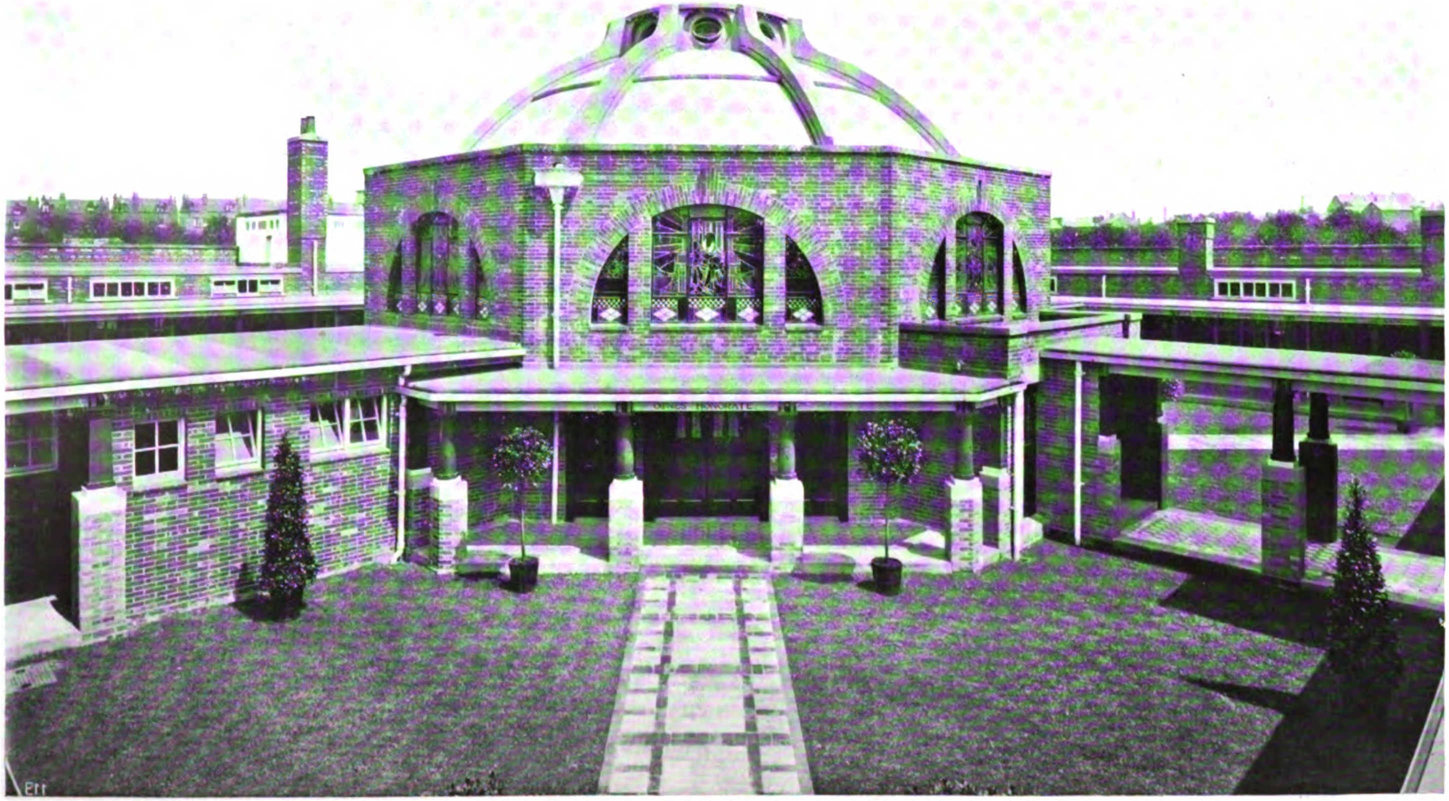


View showing Completed Building and Reinforced Concrete Dome.
REINFORCED CONCRETE AT THE ILKESTON SECONDARY SCHOOLS.
(For description see page 609)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume IX. No. 10. LONDON, OCTOBER, 1914.

EDITORIAL NOTES.

THE USES OF CONCRETE.

THE uses of Portland cement and concrete must be largely influenced at home by the state of war, and we would remind those who have not yet fully realised the great convenience of concrete as a substitute for nearly all building materials of the fact that it is a form of construction that can be used both practically and economically in the vast majority of cases where other materials fail.

In one direction there appears to be a certain failure of material for which concrete is an excellent substitute—namely, the cutting off of the supply of the ordinary cheap timber imported principally from the Baltic ports.

It has been proved time after time that timber may be not only easily replaced, but replaced with all due regard to maintenance and economy by concrete, where it is utilised in heavy scantlings. It is equally suitable for all forms of posts, from the ordinary fence post to the tall telegraph post, and in mines it can be most effectively used for pit props; while for those who work in reinforced concrete, we would remind them that light concrete struts and posts have been advantageously used to support centering and falsework in countries where timber is expensive. Another form of replacing wood with concrete, and to a certain extent wood and galvanised iron, is the concrete block and the concrete slab, and many of the small huts and temporary buildings that are as a rule erected in timber and galvanised iron can be as well, in fact better, constructed with equal rapidity in concrete slabs or blocks.

Next we would turn to the roofing materials—cement slabs in various combinations, especially in connection with asbestos, can be most usefully employed for roofing material with the additional advantage of a comparatively lower conductivity, which is of importance both in winter and in summer weather.

Where the better classes of stone have been imported for ornamental purposes, and where our own stone material may not be equally suitable or too costly to work, we would again suggest artificial stone, which is practically nothing else but concrete, and can be effectively and rapidly applied.

Altogether the architect, surveyor, engineer, Royal Engineer, estate owner, builder, and clerk of works will do well to bear in mind the enormous advantages of Portland cement and Portland cement concrete at such a time as the present, where rapidity and economy are both matters of moment.

CONCRETE FOR WAR PURPOSES.

Although correct information on military matters is rather scarce, it can be easily gleaned that concrete is playing a part in the present terrible war.

Gun bases in the field, protection to trenches, and minor field works appear to have concrete employed in them in some form or other, and for fortifications in particular we are now frequently hearing of reinforced concrete, of which little was said in times of peace.

There is no doubt that Portland cement must prove a useful auxiliary in all forms of military engineering work, and it is to be hoped that when the war is over it will be possible to collect some useful information as to the efficiency of concrete material in both field and siege work.

THE TECHNICAL PROFESSIONS AND THE WAR.

Practically the whole of the technical professions are in some form or other actively engaged in assisting the Government in matters of the War emergency. The three great engineering institutions have been particularly active in providing men suitable for special engineering work, and for recruiting in engineering units, notably Royal Engineer Reserves and auxiliaries.

The architectural bodies have offered their services to the Government and have formed an Emergency War Committee, including a benevolent side; whilst that junior and eminently active body, the Architectural Association, is not only assisting in the recruiting of units for the War Office, but is organising auxiliary forces in various forms.

The Institute of Public Health and the Royal Sanitary Institute are both doing good work; whilst the British Fire Prevention Committee has organised a Special Fire Service Force, comprising fire surveyors who undertake inspections of public establishments and hospitals; while fire service units, such as fire patrols and complete fire brigades, are made available for immediate service where the necessity arises.

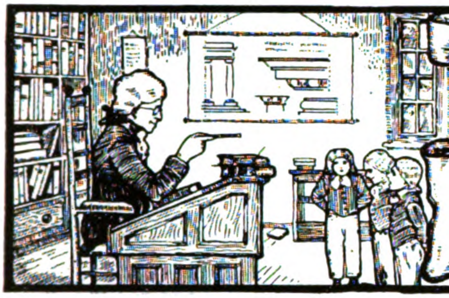
It is pleasurable to observe this active and useful work which is being carried out by the members of the great technical professions in this country, and it redounds eminently to their credit that whatever work they appear to take up, they do it well and efficiently.

It is also hoped that, with a view of avoiding unemployment, the Government, the municipalities, and other public corporations will not fail to put works in hand promptly for the coming winter, so that the building trade in its widest sense, allied with the engineering trade, which together embrace so many matters, may not feel the effects of the war too acutely, and that the professions may be called upon to assist in these works.

COTTAGES.

We would not like to labour the point at this stage that more cottage accommodation is required in our rural districts, and that the present is the moment when employment could be usefully found for many, both in preparing for and erecting the cottages that are so badly needed.

There are plenty of suitable plans for such cottages available, not least among them being the plans of cottages that were the outcome of our own Concrete Cottage Competition, whereby expenditure on timber need not be incurred at the moment. But those in authority on this matter, particularly the Board of Agriculture, we would again venture to remind that this is the time when such work should be promptly commenced.



REINFORCED CONCRETE AT THE ILKESTON SECONDARY SCHOOL.

It is becoming recognised more and more that reinforced concrete is a very excellent and suitable form of construction for school buildings, and the particulars given below will doubtless be of interest to all those interested in the question of healthy school buildings.—ED.

THE opinion was emitted some time ago, when the question of building a large number of schools throughout the country was being discussed, that reinforced concrete would probably not find any place in these buildings, owing to the fact that it would be more costly than timber or brickwork, or that for some other reasons it might not lend itself to the requirements of schools.

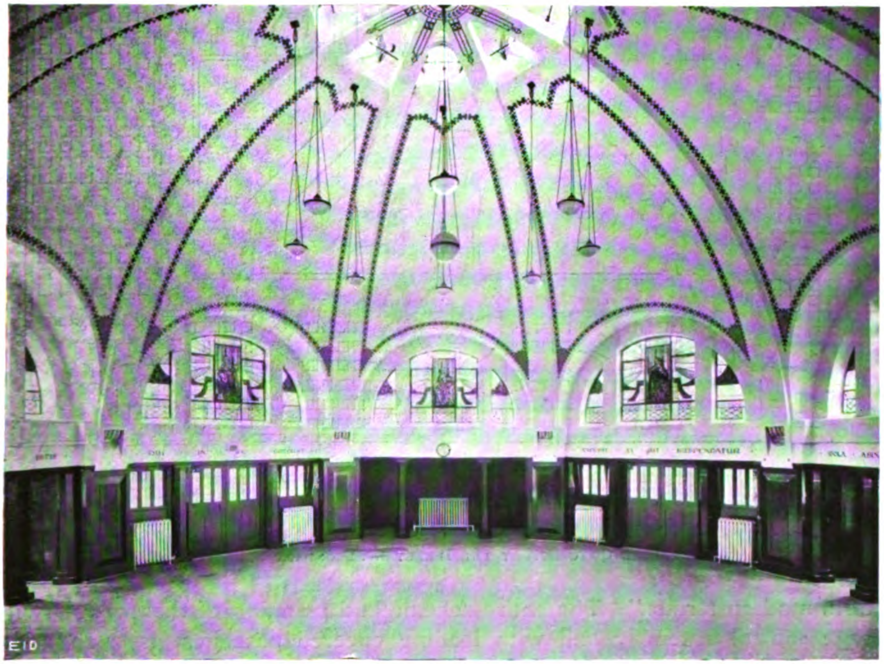
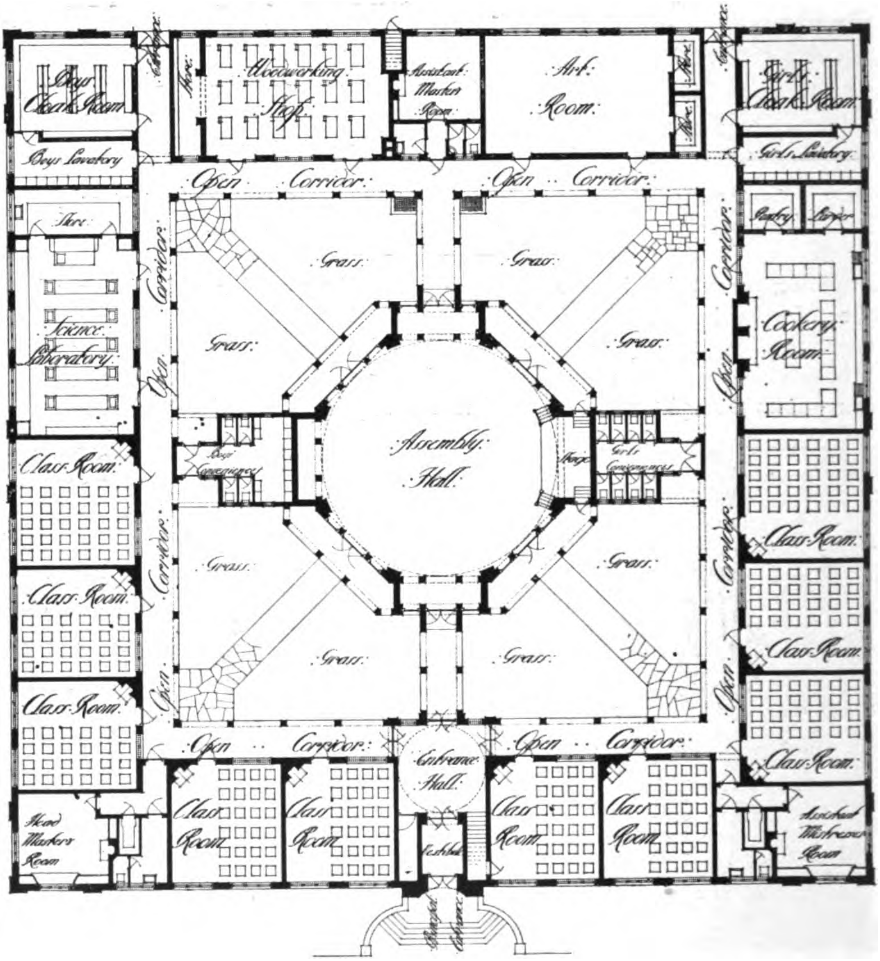


Fig. 1. The Assembly Hall.
REINFORCED CONCRETE AT THE ILKESTON SECONDARY SCHOOL.

As a matter of fact, this material has been used extensively in a large number of important schools throughout the country for floors, roofs, swimming baths, and foundations, and the new Secondary School at Ilkeston which has been recently opened by His Majesty the King, is the latest example of a large modern school in which reinforced concrete, as the latest up-to-date material, has found an extensive application.

As shown in the accompanying illustrations, the architect, Mr. G. H. Widdows, F.R.I.B.A., has fully succeeded in his attempt to express "a modern school in modern terms." The entire scheme and planning of this school, witn its large central assembly hall with leading covered passages, is a complete departure from the arrangement which is usually provided.



Fi . 2. Ground Floor Plan.
REINFORCED CONCRETE AT THE ILKESTON SECONDARY SCHOOL.

As shown in the plan, the classrooms are arranged round a quadrangle, the outside dimensions being approximately 170 ft. in width by 180 ft. in length. The total accommodation of the classrooms is suitable for 252 scholars. In addition to the ordinary classrooms, a cookery-room, art room, manual room, and science laboratory have been provided, and a certain number of special

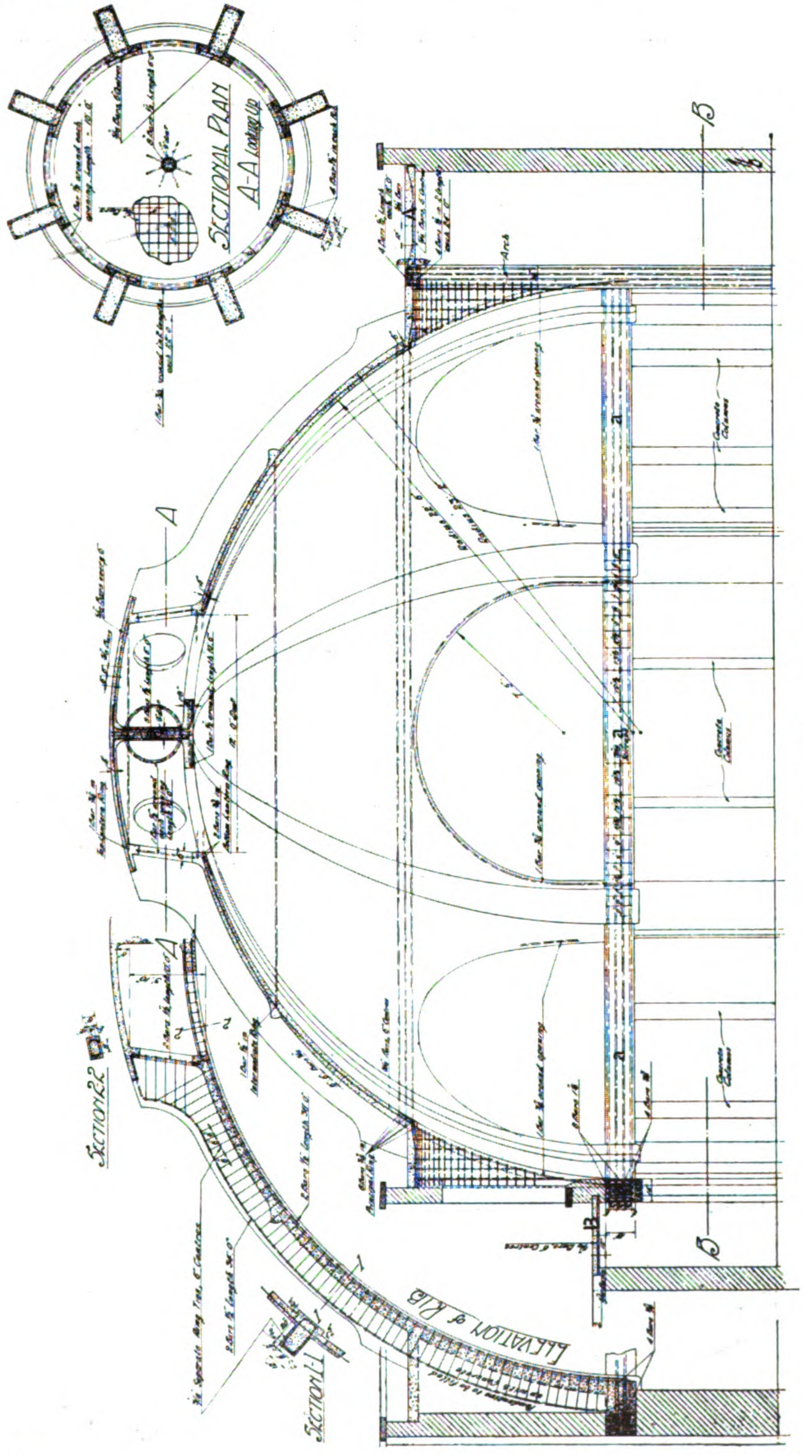


Fig. 3. Section—Reinforced Concrete Dome.
Reinforced Concrete at the Ilkeston Secondary School

rooms for the staff. The classrooms have been particularly constructed with a view to obtaining the maximum amount of ventilation.

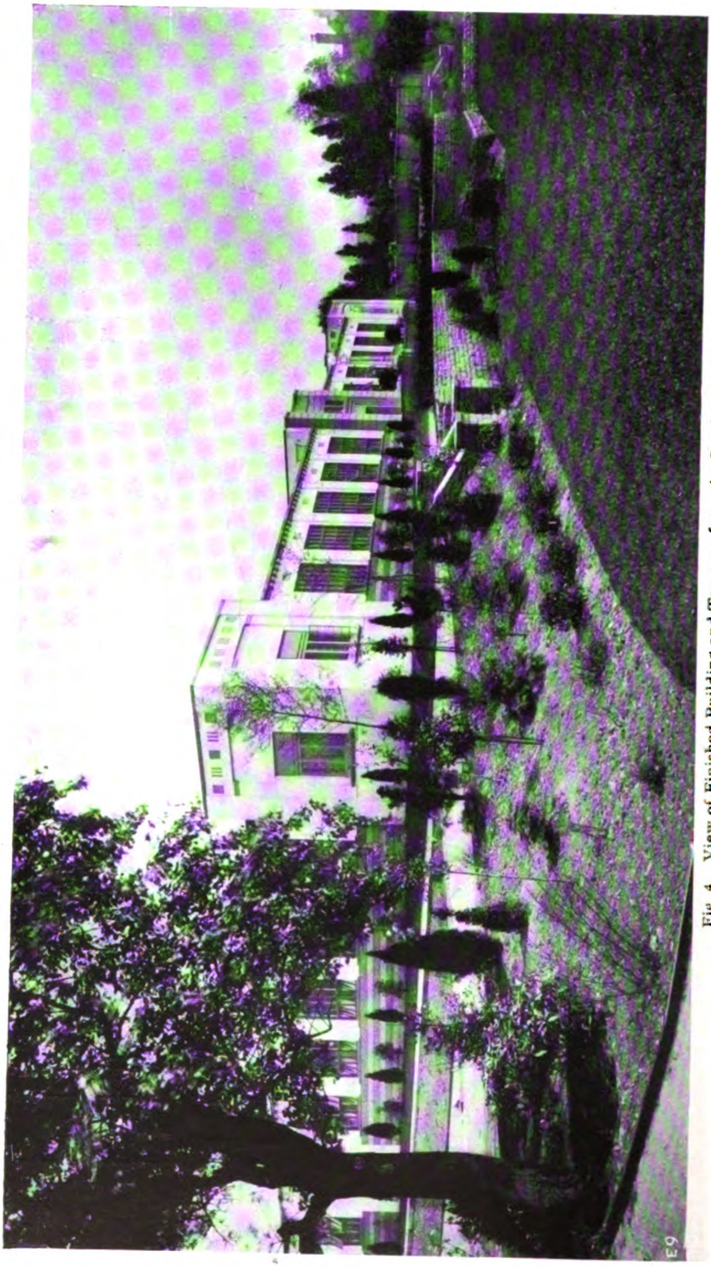


Fig. 4. View of Finished Building and Terraces from the South-west Side.
REINFORCED CONCRETE AT THE ILKESTON SECONDARY SCHOOL.

Concerning the architectural treatment, this building is clearly in accordance with the modern style in which a certain amount of colour is introduced, either by means of coloured bricks or stained glass, as well as by the general shape of the various parts of the structure.

The Coignet System of reinforced concrete was used for the construction of the dome, which has a diameter of about 45 ft. The whole of the flat roofs and suspended floors are also constructed on this system, which has been extensively used for many other schools.

The reinforcement employed throughout the work was composed of round bars, varying in diameter between $\frac{3}{16}$ in. and $1\frac{1}{4}$ in. The ribs shown on the outside of the dome are simply provided for decorative effect.

All the reinforced concrete work was executed by Messrs. Evans Bros., of Alfreton, Licencees of the Coignet System. The general contractor for the work was Mr. A. Earnshaw, of Ilkeston.

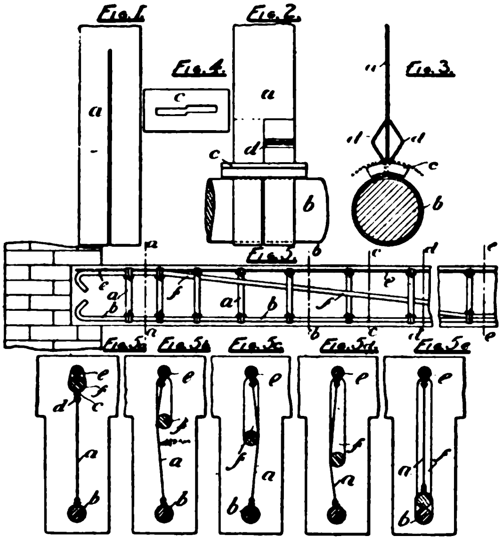
As shown in the general view, the building has been erected on high ground, which has been arranged in the shape of a double terrace. The lower ground is used as a playing field, and a large number of shrubs and trees contribute to enhance the architectural appearance of the building.

All the plans for the reinforced concrete work were prepared by Messrs. Edmond Coignet, Ltd., of 20, Victoria Street, Westminster, S.W.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

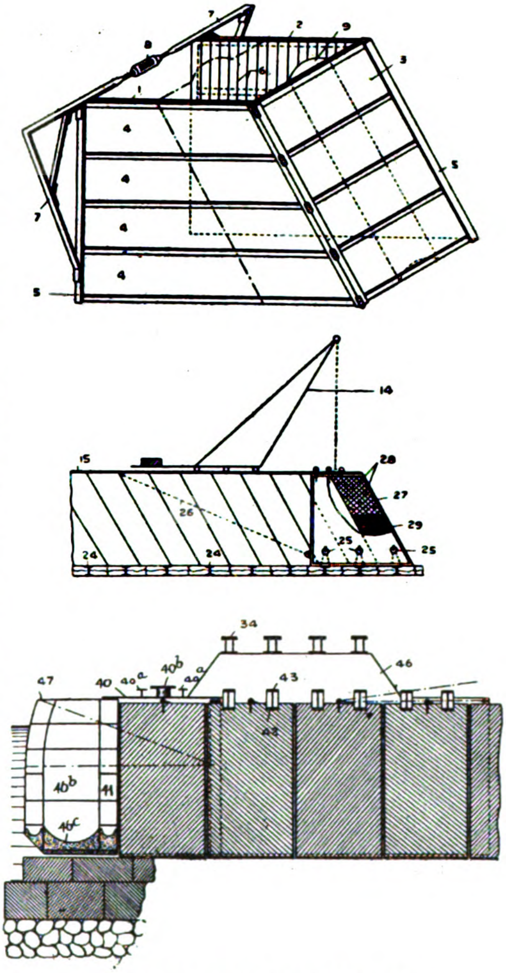
We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. The last article appeared in our issue of July, 1914.—ED.

Ties for Reinforcement.—*No.* 5,192/14. *W. J. Stewart and J. Woolcock. Accepted May* 7/14.—This invention comprises improvements in ties for reinforcements for concrete work, according to which the beam and other reinforcements can be made up suitable for immediate placing in the moulds, thus dispensing with tying wire. The tie is formed of a band (*a*) of hoop steel or the like of the required length. This band is split or divided for a short distance at one or both ends, and the divided parts are bent in opposite directions and passed round the reinforcing bar (*b*) and brought close to the main parts (*Figs.* 2 and 3). A collar (*c*) (*Fig.* 4), formed with a stepped slot, is passed along the band and over the ends of it, and the ends (*d*) are then bent outward from the band in any suitable manner which will secure the collar in position (*Figs.* 2 and 3), or may be simply turned down as shown in dotted lines. The tie can be applied to the reinforcement of a beam (*Fig.* 5). The tie (*a*) at one end is attached to the tension bar (*b*), and by its upper end to the compression bar (*e*) and also to the camber bar (*f*) (*Fig.* 5a), which is a section on the vertical line (*a—a*) of *Fig.* 5. Between the upper and lower straight parts of the camber bar (*f*) the ties (*a*), clipped to the bars (*b*) and (*e*), are placed alternately to pass on different sides of the camber bar (*Figs.* 5b, 5c, and 5d). *Fig.* 5e is a sectional view on the line (*e—e*) (*Fig.* 5), and shows the tie (*a*) clipped to the upper bar (*e*), and at its lower end to the camber bar (*f*) and lower rod (*b*). The tie can also be applied in various ways to reinforcements for walls, columns, or floor slabs.



Figs. 1—5. TIES FOR REINFORCEMENT.

Breakwaters, Piers, etc.—*No.* 9,701/13. *E. Gallo. Accepted March* 26/14.—This invention comprises an improved method and apparatus for building breakwaters, piers, and like concrete structures, by casting blocks *in situ*, the concrete mixture being filled in under water. The casting is carried out in a caisson with no bottom, made up of three walls, *viz.*, two side walls arranged parallel to the axis of the pier and a cross wall, which are connected together either by hinge-joints or by a rigid connection. The two side walls are fitted with a device which allows of the caisson being strongly secured by means of the walls to such portion of the work as has been previously built in the usual way. The fourth wall is formed by the face of the last built block or of the pier to be lengthened, and the bottom is formed by the foundation reef or by the sea bottom. The caisson, in addition to its being fastened by a part of the two side walls, can be secured to the bottom, for instance, by means of ties fastened to rings secured to the bottom, on which the caisson can rest if the bottom be made up of artificial blocks. The foundation on which the caisson itself rests can be made up of a number of beams set in place beforehand as the work progresses, such beams being made use of to secure the caisson mooring rings. Such portions of the walls as are used for moulding the block in the casting process can be lined with sheet iron, netting, or any other suitable material to prevent the concrete from sticking to the movable walls. The caisson is made up the walls 1, 2, 3, the wall 3 being placed transversely to the length of the pier or quay, and preferably having a slope or otherwise. The walls are built either of plates (4) or gratings, reinforced with angle iron (5), and lined inside with strips of wood (6), or of any other suitable material. The side walls (1 and 2) are secured by a hinge joint (5) on the wall (3), and the distance between their free ends is controlled by a frame (7) by means of a screw coupling (8). The wall (3) is provided interiorly with a projection (9), intended to mould in each block a recess whereby it is bonded to a neighbouring block. By means of a crane (14) travelling on rails (15) the caisson is moved forward as far as advisable. The walls (1 and 2) are moved away from each other by means of coupling (8), and when the caisson has reached the desired position the walls are brought towards one another till they press heavily against one or more of the previous blocks, the caisson being thereby firmly secured. Once the caisson is in place, the filling in of the space enclosed by the seaward face of the last block built, and by wall (3) and side walls (1 and 2), is proceeded with, the travelling crane (14) being conveniently used for delivering the mixture. In the space to be filled there can be arranged the iron reinforcement (28) of the block, and along the side walls the sheets or gratings intended to protect them against wave impact immediately on the block being cast and released. In a modified construction in which the caisson is to be used for compressed air work, it is provided at its upper end with an air-tight hinged or sliding door, and with an equalisation chamber, also along the free edges of the side walls with suitable packing to ensure air-tightness. Such packing can be made of india-rubber pipes adapted to exert pressure in suitable grooves made in the block last built. By securing the caisson to girders underlying the blocks already built, these assist in holding the caisson against a tendency to upward lift. In a modified construction, *Fig.* 3, the caisson has buoyant side and cross walls (46b). This form of caisson may be stiffened by cross beams (34). Below the upper stiffening beams (34) lower cross beams (43) are arranged, and the latter may be at such a level that the blocks are cast about part of them, so that they enter hollow channels (42) across the upper parts of the blocks; this arrangement tends to reduce longitudinal stresses in the caisson and to obviate displacement of the caisson in the direction of the axis of the pier.



Figs. 1—3. Breakwaters, Piers, etc.

Centering for Concrete Floors.— *No.* 22,795/13. *C. Tomkinson and J. T. Williams. Accepted April* 30/14.—This invention comprises an arrangement of centering suspended entirely from the girders, thus rendering unnecessary supporting poles or hangers. The whole apparatus in accordance with this invention can be easily removed after the concrete has been put in, as the cross beams or joists are supported between the girders somewhat in cantilever manner by devices overlapping the girders, and can be easily taken down though wedged or screwed tightly in position so that they cannot slip. The centering joists are carried from the girders either by means of straps round the joists holding the wedges, one of which rests with its end on the bottom flange of the girder, or they rest on plates bolted by one lug bolt on each side of the girder, the lug passing over the bottom flange of the girder and two wedges being driven in through a slot in the bolt below the plate.

In *Figs.* 1 and 2 the girder (*A*) carries the centering joist (*B*) by means of a strap (*C*) suspended over the joist and having a bolt or abutment (*D*). The wedge (*E*) holding on to the lower flange of the beam (*A*) is held up by the wedge (*F*) driven in between the abutment (*D*) and the wedge (*E*). The concrete is held up by the sheathing (*K*). By driving out the wedge (*F*) the whole centering comes down.

In the form shown in *Fig.* 3, iron wedges are employed, and lug bolts (*H*) pass through a flanged plate (*G*) under the beam (*A*), and their lugs rest on the lower flange of the girder. Two wedges (*I* and *J*) are driven through a slot in the lug bolt so as to held the plate tight against the beam.

The lug bolt could be screwed and nuts take the place of the wedges, but wedges are preferable, as it is often difficult and dangerous to unscrew nuts, whereas wedges can be knocked out by a simple blow of the hammer.

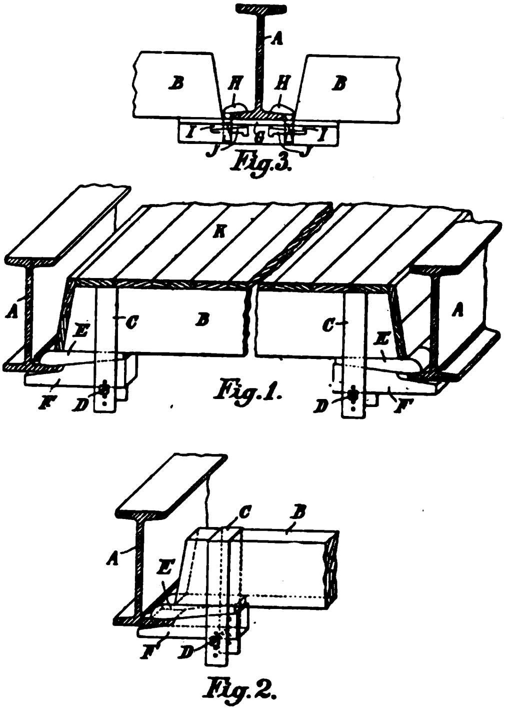


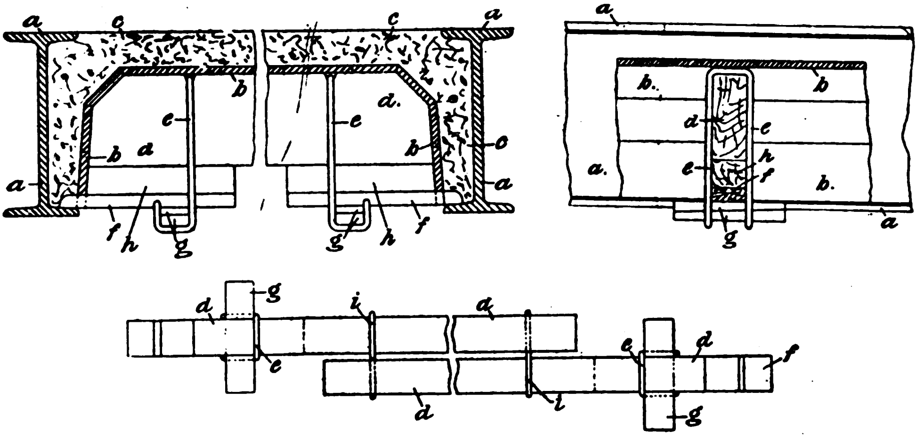
Fig.3.

Fig.1.

Fig.2.

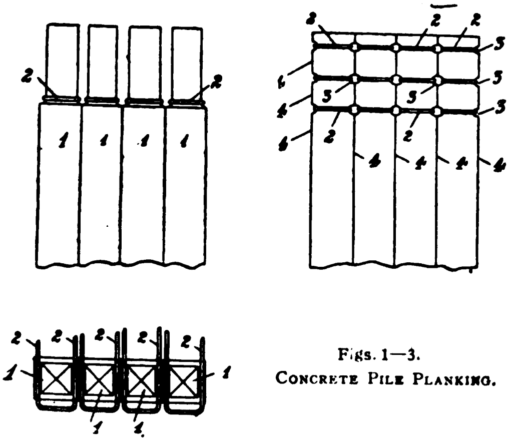
Figs. 1—3. Centering for Concrete Floors.

Concrete Floor Centering. — *No.* 28,103/13. *T. Higson and R. L. Burns. Accepted April* 2/14.—This invention refers to centerings or supports for concrete floors which are supported at certain distances apart by metal joists or girders, particularly to that type of centering in which the concrete supporting boards are carried by transverse beams of wood, supported from the lower flanges of the floor girders or joists through wedges fitting under bars under the cross beam ends and resting on the lower flanges of the floor joists, the transverse centering beams being less in length than the distances apart of the flanges of each pair of floor girders. The chief object of the invention is to provide a centering which avoids the use of all screw bolts or nuts, and which, being supported by hanger hooks from a removable part of the centering, is adapted to be used over and over again, and can be erected and taken down in a relatively short time. Steel girders (*a*) form the main supporting means of a floor, and the floor spaces between these joists are filled with concrete (*c*). The centering or moulding bars (*b*) are carried by wooden transverse beams (*d*), spaced at suitable intervals apart. The bars (*f*) extend beyond the ends of the transverse beams (*d*) and rest on the lower flange of the girders, while wedges (*g*) are supported by the double hook hangers (*e*) and lie beneath the bars (*f*). Filling blocks (*h*) are placed between the bottom of the transverse beam (*d*) and the bar (*f*). In use, when the concrete flooring has been introduced and set, the centering is simply removed by knocking away the wedges (*g*), whereupon the lower bars (*f*) are unsupported, and the beams (*d*) and centering boards (*b*) can be simply dropped down between the flanges of the girders (*a*) without having to undo any bolts, nuts, or screws, which are troublesome in use, as water and cement cause them to get rusted or cemented up. In cases where the distances apart of the flooring girders are variable, the transverse centering joists (*d*) are made in two parts (*Figs.* 3), arranged to overlap each other as shown between the girders, and they are supported and fixed together by two or more " S " shaped hooks (*i*), the outer end of each joist member (*d*) being supported by the lower part of the hook (*i*), while the upper part fits over the top of the other joist member.



Figs. 1—3. CONCRETE FLOOR CENTERING.

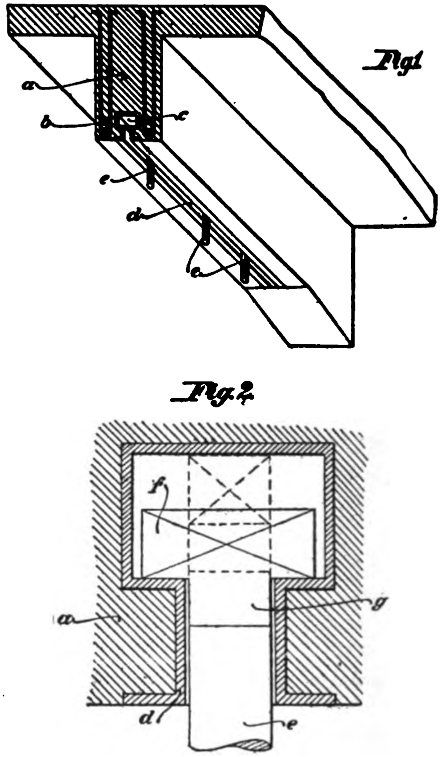
Concrete Pile Planking.—*No.* 23,859/13. *H. G. C. Fairweather. Accepted April* 2/14.—This invention relates to concrete pile planking of the type in which the cross-section of the upper end of each pile is reduced wholly or in places, so that spaces are left between the heads of the piles. In accordance with the invention reinforcing rods for the upper concrete layer, for instance the top or head structure of a quay wall, are introduced between the spaces, thus allowing a good connection between the pile planking and the upper layer. The horizontal reinforcing rods, 2, *Fig.* 1, for the upper structure are inserted in the spaces between the piles, 1. Concrete or cement is then poured into these spaces until they are completely filled up. In the construction shown in *Fig.* 2 the upper ends of the piles are merely provided with grooves, 3, at the sides; the reinforcing rods, 2, are introduced into these grooves. This construction has the advantage that, in driving the piles, they are well guided on their surfaces throughout their length. Every second pile may be constructed as usual without any groove or reduction in its cross-section at the upper ends, so long as they alternate with piles to allow the reinforcement to be employed in the above manner.



Figs. 1—3.
CONCRETE PILE PLANKING.

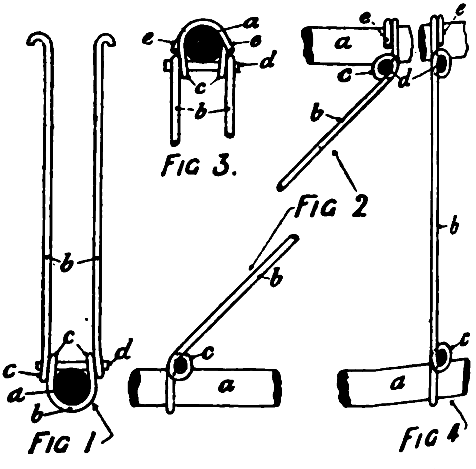
Reinforced Concrete Ceilings, etc.— *No.* 1,900/14. *Dr. B. Bauer. Accepted May* 28/14.—This invention relates to an improved reinforced construction of the kind in which the concrete body is provided with a slot of T-shaped cross-section for guiding suspension bolts or the like, in order that lighting elements, line shafts, and similar devices can be connected to the reinforced concrete body and secured at any desired point therein without having to alter it. According to the invention, the T-shaped slot is formed of rolled channel iron, which is used for guiding the suspension bolts, and at the same time forms part of the main reinforcement.

The girder *a* of the reinforced concrete roof (*Fig.* 1) is strengthened in addition to the usual strengthening rib *b* of round rods by a T-shaped channel rolled iron section *d*, in the space *c* of which the heads of the bolts *e* can slide. The bolts *e* have a T-shaped head *f* (*Fig.* 2), which is of such a cross section that it can be introduced through the narrow portion of the channel *d*. The widened T-shaped head of the channel must be made so high that the bolts *e* can be turned through an angle of 90° (*Fig.* 2) so that the bolt head *f* rests on the shoulder of the channel *d*, the narrower square portion *g* of the bolt head being guided by the lateral walls of the channel and so prevented from turning. If all the roof girders of a building are provided with such continuous and strengthened slots, when the building is finished alterations in the arrangement of the inner equipment can be carried out directly without any alteration of the finished reinforced concrete construction.



Figs. 1 & 2. Reinforced Concrete Ceilings, etc.

Stirrups for Reinforced Concrete.—*No.* 28,207/13. *A. J. Luke. Accepted July* 23/14.—This invention comprises an improved form of stirrup or other subsidiary reinforcement of concrete, which can be attached to main reinforcements at any desired angle. The improved stirrups comprise a rod formed with an open loop passing under or over a main reinforcement member, and thence up or down the sides of the latter, two complete loops or turns (one on each side of the main reinforcement) being formed to take a pin or wedge for securing to the main reinforcement. *Figs.* 1-4 show alternative forms of stirrup. The stirrups, *b*, have complete loops, *c*, formed in them to take the pins or wedges, *d*, by which they are fixed to the main reinforcement, *a*.



Figs. 1—4. Stirrups for Reinforced Concrete.

Column and Pile Reinforcement. — *No.* 7,743/14. *T. B. Cooper and C. E. Holloway. Accepted July* 16/14.—This invention consists in an improved reinforcement for use in columns, piles, and other reinforced concrete constructions. The improved reinforcement comprises the combination with reinforcing rods of links, each of these links being made in one piece of steel wire throughout, and approximating to the configuration of two triangles, connected at their apices by twisting the ends of the wire around one of the limbs. The link consists of one piece of steel wire shaped to resemble two triangles, which are connected by twisting the ends, *a*, of the wire about the limb, *b*, which is undivided. In applying such links to the reinforcing rods, the links, having been previously made up, are strung on the rods or bars, *c*, and are adjusted to their assigned positions. The links are then secured, either by wiring them to the rods or bars, *c*, or by the stretching action of the struts, *d*, which are of the usual kind employed for stiffening such structures and keeping the links taut. The links may be applied either way up, and it is preferred in some structures to have them alternating in respect of the way up, as shown on the drawing.

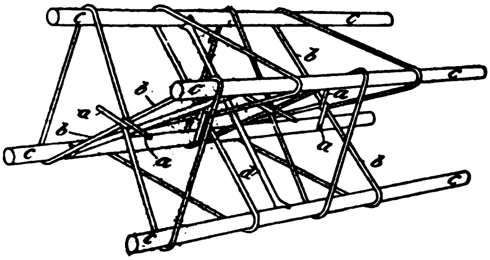


Fig. 1. Column Reinforcement.

OUR CONCRETE COTTAGE COMPETITION.

FURTHER DESIGNS SENT IN.

With Design No. 76. (By Chas. B. Pearson, 109, High Road, Chiswick, W.)

Description and Remarks.

THE author has endeavoured to carry out the conditions of the competition. The areas of the rooms have been closely adhered to, and the accommodation provided is in his opinion consistent with cost.

Concrete to be used wherever possible and the amount of woodwork reduced to a minimum. This being necessary in the case of doors, cupboards, etc.

It is proposed that the floors and roof be of concrete. The floor surfaces to be finished with a patent composition, such as "Doloment," or other approved method.

The roofs to be covered with approved concrete tiles. If not contrary to the spirit of the competition, it is suggested that a good coloured red tile would form a very fine contrast to the other portions of the buildings.

The walls and chimney stacks to be in concrete built *in situ*, the interior partitions to be in slab concrete. The external faces of the walls where shown on drawings to be finished in plaster or rough-cast trowelled smooth.

All woodwork has been eliminated from windows, the method proposed being shown on the details.

Specification.

Materials.—The cement to be best Portland, complying with the requirements of the Specification adopted by the British Engineering Standards Committee.

The sand to be from a well-known local pit; it should be clean and free from organic or earthy matter, and washed if required. The aggregate to consist of a good local material, consisting of gravel, hard stone, or other suitable material, should be clean and regular, varying in size, all to pass through a ¾-in. mesh. The proportions of concrete should consist of 1 part cement, 1½ of sand to 2½ parts aggregate.

The concrete should be mixed in small batches and in accurate proportions, and should be laid as rapidly as possible. The amount of water to be added depends on the temperature at time of mixing. Clean, fresh water only to be used.

The centering or casing to be so constructed as to remain rigid and unyielding during the laying and punning of the concrete, and should be arranged to permit of casing and removal without jarring of concrete.

All other materials to be the best of their respective kinds, free from all defects.

Statement of Cost.

The cubical contents are 14,600 cub. ft. per pair. This is arrived at as follows:—

		ft.	in.
Main block, 47 ft. 3 in. × 15 ft. 6 in. × 18 ft.	=	13,546	0
W.C.'s, 9 ft. 3 in. × 3 ft. 3 in. × 15 ft. 3 in.	=	900	0
Chimneys, 2, 4 ft. × 3 ft. 6 in. × 1 ft. 6 in.	=	42	0
Chimney, 6 ft. × 2 ft. 6 in. × 3 ft. 6 in.	=	52	0
Dormers, ½, 30 ft. × 4 ft. × 1 ft.	=	60	0
		14,600	0

Estimated Cost for Pair

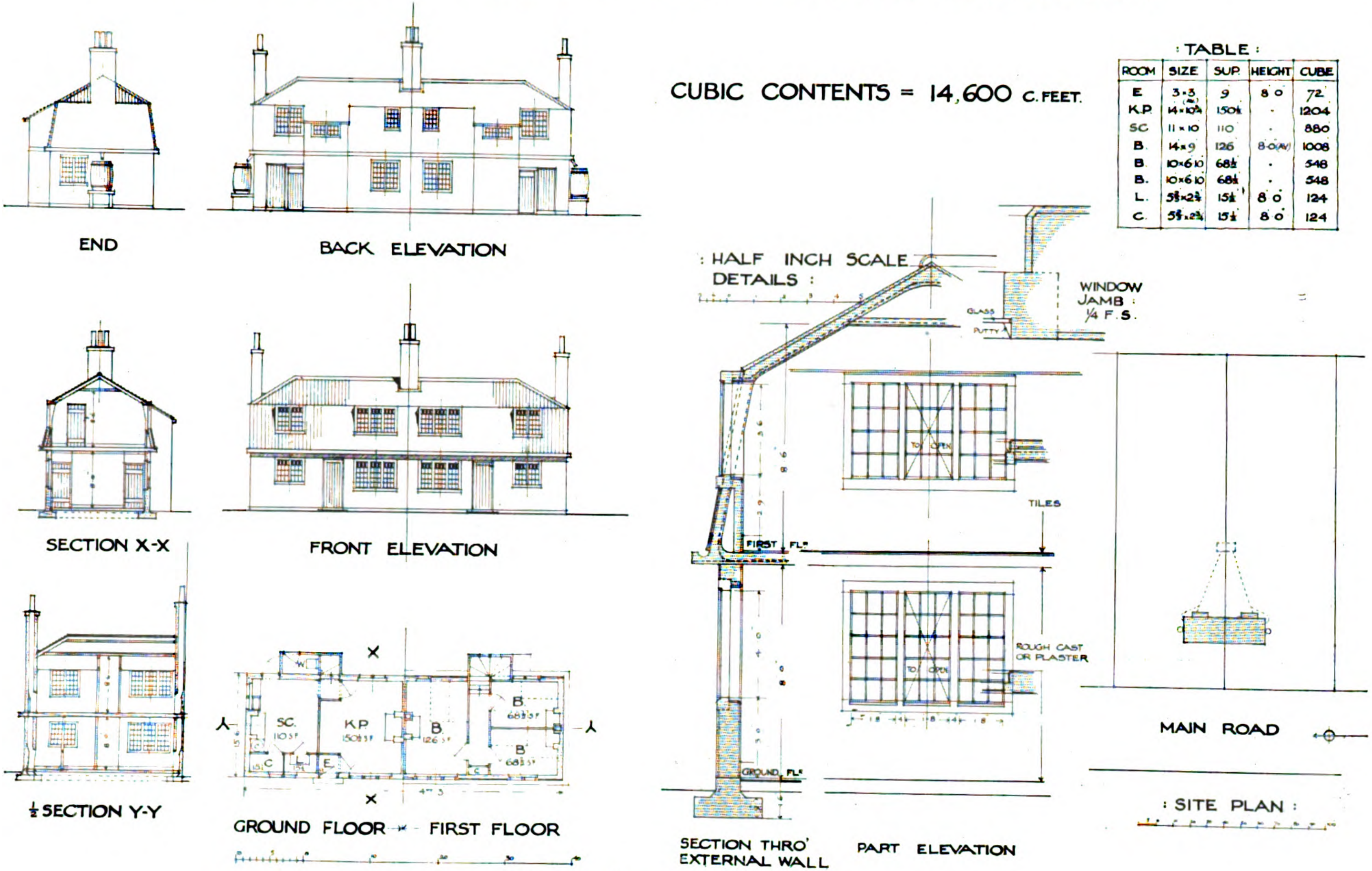
= 14,600 cub. ft. @ 4⅛d. = £250 18s. 9d. per pair = £125 9s. 4½d. per single cottage.

It is considered that the price per cubic foot, 4⅛d., is sufficient, seeing that there is no fencing, paths, water supply plumbing, or land drainage to be included and that the cottages are to be put up in a series of six.

List of Fittings, &c.

	£	s.	d.
Kitchen Range	3	5	0
Scullery Range	2	0	0
Washing Copper	1	10	0
Bedroom Fireplaces (3)	4	0	0
Dresser	2	0	0

CONCRETE COTTAGE COMPETITION



: TABLE :

ROOM	SIZE	SUP.	HEIGHT	CUBE
E.	3×3	9	8' 0"	72
K.P.	14×10¾ (av.)	150½	·	1204
SC.	11×10	110	·	880
B.	14×9	126	8-0 (AV)	1008
B.	10×6 10	68½	·	548
B.	10×6 10	68½	·	548
L.	5⅝×2¾	15½	8' 0"	124
C.	5⅝×2¾	15½	8' 0"	124

DESIGN No. 76 ... BY CHAS. B. PEARSON.

With Design No. 97. (By E. W. Stubbs, Grayshott, Marlborough Road, South Croydon.)

General Description.

SPECIAL attention has been given to rendering these cottages as simple as possible, both in design and construction. The plan provides access to fuel store and w.c. under cover of a lobby, while access from bedrooms to w.c. is arranged without the necessity of passing through the living room.

The porches shown are to have the sides covered with trellis, on which could be grown, say, crimson rambler or clematis, thus providing shelter to the entrance, and affording a pleasing and appropriate form of ornament.

The walls are substantially constructed of hollow concrete blocks 8 in. thick, covered externally with cement rough-cast as an additional precaution against the weather.

The internal finish to consist of the smooth face of blocks finished with two coats of washable distemper.

Standardisation of doors and windows has been adopted throughout, and the chimneys and fireplaces are to be formed of special 4-in. blocks.

The simplicity of the construction will be evident on reference to the plans, which show foundations, floors, and roof in complete detail.

Short Specification.

Foundations.—As shown, of concrete, composed of 6 parts clean ballast, free from loam, to 1 part Portland cement.

Walls.—To be built of hollow concrete blocks, sizes 16 in. by 12 in. and 8 in. by 12 in., all 8 in. on bed, made on the site with a block-making machine. The concrete to be composed of 5 parts clean ballast with the sand left in, all to pass a ¾-in. ring, 1 to 2 parts clean, well-graded sand, and 1 part Portland cement.

Sufficient sand is to be used to correctly fill the voids in the aggregate, the exact amount to be determined by trial. The blocks are to have one face roughened to afford a key for the rough-cast.

The damp course to be of bitumen sheeting with cement plinth externally and cement skirting internally.

The walls to be covered externally with cement rough-cast, whitewashed; internally they are to have the joints wiped off smooth whilst wet, and two coats of Hall's washable distemper.

Lintols to be formed *in situ* of concrete as described for blocks, reinforced with two ¾-in. steel rods.

Floors.—Ground floor to have 4-in. bed of 1 to 5 concrete on hard core foundation; living room and entrance lobby to be tiled with cement tiles 6 in. square and ¾-in. thick, those in the living room to be coloured red, and in the lobby to be red alternating with black. These tiles would be made on the site with the machine.

The floors of the scullery, back lobby, lobby, larder, w.c., and fuel store are to be cement-finished granolithic.

The first floor is to be constructed with 9 in. by 2 in. joists and 4-in. by 3-in. plates, supported on wrought-iron corbels every 3 ft. apart. Lath and plaster ceiling, 1-in. deal batten flooring, laid folding, with 4-in. by 1-in. deal skirting.

The hearths to be concrete, finished fair in cement.

Roof.—To be constructed of plates 5 in. by 4 in, rafters and collars 4 in. by 2 in., and ridge 7 in. by 2 in., and to be covered with corrugated cement tiles coloured white, and made on the site with the machine.

Ceiling and cove to be plastered, and eaves to have 5 in. half-round eaves, gutters supported on brackets screwed to rafters, and 3-in. R.W. pipes.

Partitions.—3-in. concrete partitions built with slabs made on the machine, and finished in the same manner as the walls.

Doors.—Entrance porch to have concrete step finished granolithic, 4-in. by 4-in creosoted deal posts, cement tile roof, and weather boarded gable. Entrance door to be 1¾-in. deal, lower part bead butt, upper part glazed with crystal hammered glass. Frame to be 4 in. by 3 in.

Internal doors to be ledged and braced doors, covered with ¾-in. match boarding in narrow widths, and hung to 4-in. by 2½-in. frames, and finished with 2-in. double-chamfered architraves.

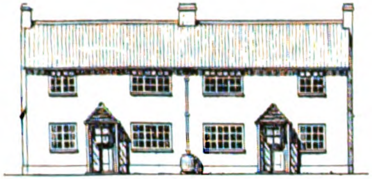
Windows.—To have cast concrete cills, as shown, forming window board internally, and moulded on the machine.

4-in. by 3-in. deal frame and mullions, 4-in. by 3-in. oak sills, 1¾-in. ovolo moulded casements glazed with 15-oz. sheet glass.

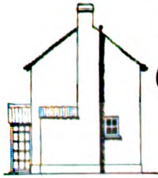
Frames to be kept 1 in. forward from face of wall, and grooved for rough-cast, with 4-lb. lead flashing at top.

Painting.—All woodwork to be painted three oils in addition to priming, and all ironwork to be painted three oils.

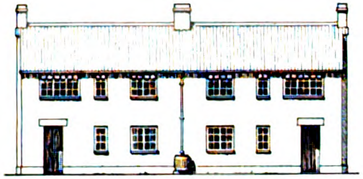
PROPOSED PAIR OF CONCRETE COTTAGES



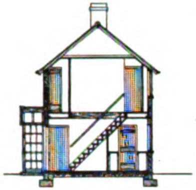
West Elevation.



South Elevation.

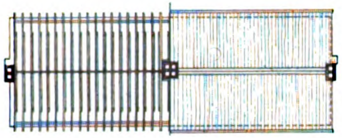


East Elevation.

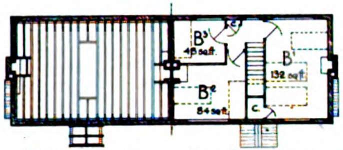


Cross Section.

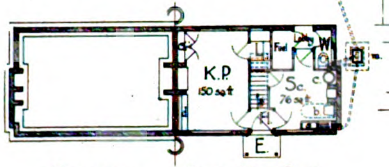
1/8 Inch Scale.



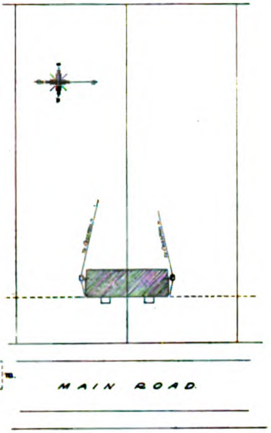
Roof Framing. Roof Plan.



Floor Framing. First Floor Plan.



Foundations. Ground Floor Plan.

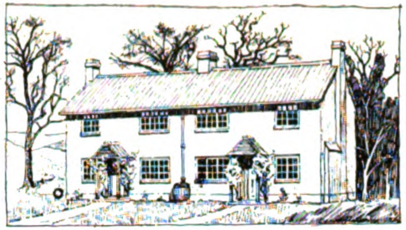


Block Plan.
1/32 Inch Scale.

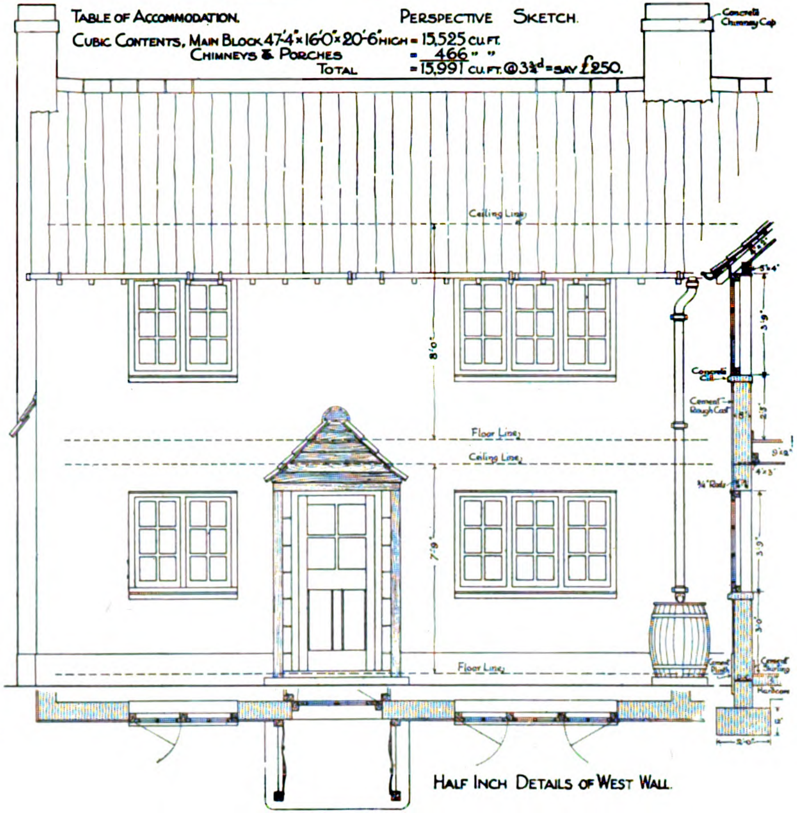
Name of Room	Size	Area	Height	Cubic Contents
Living Room (KP)	14'8"×10'8"	150 sq.ft.	7'9"	1160 cu.ft.
Scullery (Sc)	9'0"×8'6"	76 " "	7'9"	590 " "
Bed Room (B¹)	14'8"×9'0"	132 " "	8'0"	1020 " "
Bed Room (B²)	10'8"×8'0"	84 " "	8'0"	650 " "
Bed Room (B³)	7'6"×6'6"	48 " "	8'0"	380 " "

Table of Accommodation.

Cubic Contents, Main Block 47'4"×16'0"×20'6" high = 15,525 cu.ft.
Chimneys & Porches = 466 " "
Total = 15,991 cu.ft. @ 3¾d = say £250.



Perspective Sketch.



Half Inch Details of West Wall.

Design No. 97 ... By E. W. Stubbs

List of Fittings.

Living Room.

Cottage range with raising fire and oven, p.c. £3 10s.
Dresser, fitted with pot-board, drawers, and shelves.
Cupboard, fitted with four tiers of 1-in. deal shelving, 1-in. cupboard front, and ledged and braced doors.

Scullery.

Hob Stove, p.c. 17s. 6d.
16-gallon portable copper connected to flue of stove.
Concrete sink with draining board and 1½-in. waste trapped to discharge over gulley.
Folding bath, 5 ft. long, p.c. £3 19s. 6d., with fixed waste trapped to discharge over sink gulley
Two tiers 1 in. deal shelves, 9 in. and 7 in. wide.

Larder.

Lower shelves 1½ in. concrete slabs on wood bearers; upper shelves 1 in. deal.

W.C.

Pedestal closet complete with birch seat, 2-gallon galvanised cistern and brackets, and galvanised pull, p.c. £1 15s.

Bedrooms.

Mantel register stoves, p.c. 10s. each in all bedrooms.
Cupboards as shown, fitted with hanging rail and hooks.

Estimate of Cost.

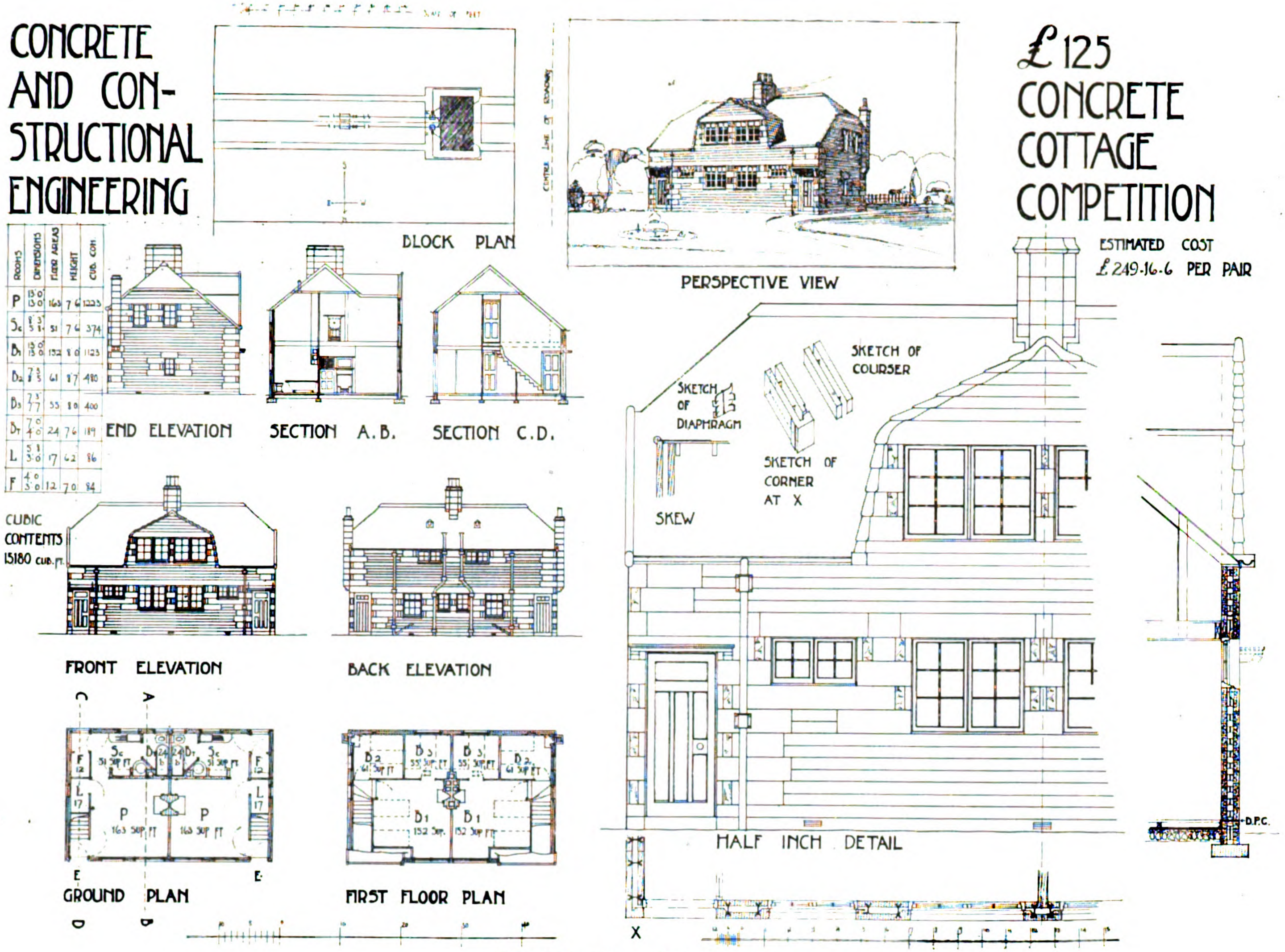
An approximate estimate of cost has been arrived at as follows:—

	£	s.	d.
1. *Foundations.*—24 yds. cube digging @ 1s.	1	4	0
12 yds. cube concrete @ 12s. 6d.	7	10	0
2. *Ground Floor.*—75 yds. sup., including digging, hardcore, 4-in. bed of concrete, and floor finishings, @ 6s.	22	10	0
3. *Walls.*—290 yds. sup. concrete block walling, including damp course, rough-cast, and finishings, @ 5s.	72	10	0
4. *First Floor.*—6½ squares, including timbers, ceiling, and flooring, @ £3 2s.	20	3	0
5. *Roof.*—10½ squares, including timbers, ceiling, lathing, and tiles, @ £2 17s. 6d.	30	4	0
6. *Windows.*—292 ft. sup., including frames, fittings, glazing, and painting, @ 1s. 6d.	21	18	0
7. *Doors.*—Including frames, fittings, glazing, and painting:—			
Entrance doors, 46 ft. sup. @ 1s. 6d.	3	9	0
Internal doors, 273 ft. sup. @ 10d.	11	8	0
8. *Staircases.*—Two, complete	5	0	0
9. *Partitions.*—155 yds. sup. concrete block partitions, including distemper both sides, etc., @ 3s.	23	8	0
10. *Fittings.*—Including ranges, stoves, grates, cupboards, dressers, eaves gutters, R.W.P., porches, etc.	30	0	0
TOTAL	£249	4	0

With Design No. 158. (By J. K. Frazer, Silverwells Crescent, Bothwell, N.B.)

Description of Building.

THE accompanying design in the CONCRETE AND CONSTRUCTIONAL ENGINEERING competition for labourers' cottages has been worked out on the semi-detached principle. The outer walls are built throughout with hollow concrete blocks in lengths of about 2 ft. 9 in., the two faces moulded together with galvanised iron diaphragms or ties. The general body of the walling would be in "fine dabbed" 6-in. courses, random jointed, and the corners, door, and window rybats and chimney stalks would be in 12-in. plain or "angle batted" courses. Partitions would be 3 in. thick and party walls 4½ in. thick, of breeze concrete in 12-in. courses. The foundations concrete, and the whole area under wood and concrete floors to have a ¾-in. layer of rough asphalte. Door and window lintels would be of reinforced concrete. There would be absolutely no connection between the outer and inner faces of walls except by the iron diaphragms or ties, and these would be grooved vertically in their centre, in order to check or arrest any moisture tending to pass along from the outer to the inner face. Lathing and strapping is thus dispensed with, and at the same time freedom from wall damp is assured at every part of the structure. Walls in apartments would have a 3/16-in. coat of plaster finished white; those in the scullery, bathroom, etc., moulded smooth and flush pointed with cement in the joints. The outside of the building has been treated very simply, exposed woodwork being at a minimum, so that the annual upkeep would thereby be reduced. In order to obtain a little contrast in colour and an artistic appearance, the following courses would be moulded in white cement: apex course and skews at bedroom windows, skews and eaves courses on gables, 6-in. course at ground-floor level, the raised back fillet on alternate corners of rybats, corners, etc., and courses at level of window lintels. All other work would be moulded to the natural grey colour of the cement, the 12-in. course at ground level being in "broached" or "rock-faced" work. Roof covering would be 11¾-in. by 11¾-in. diagonal "Eternit" slates, blue in colour. If the copper be raised slightly and a draw-off tap taken through the wall and over the edge of bath, hot water would thus be readily obtained.



ROOMS	DIMENSIONS	FLOOR AREAS	HEIGHT	CUB. CON.
P	13' 0" 13' 0"	163	7 6	1223
Sc	8' 3" 5' 1"	51	7 6	374
B1	13' 0" 13' 0"	152	8 0	1123
B2	7' 3" 8' 5"	61	8 7	480
B3	7' 3" 7' 7"	55	8 0	400
DT	7' 0" 4' 0"	24	7 6	189
L	5' 8" 3' 0"	17	6 2	86
F	4' 0" 3' 0"	12	7 0	84

DESIGN No. 158 ... BY J. K FRAZER.

Specification for Making Concrete Blocks.

The concrete blocks for 6 in. courses to outside walls would consist of an outer slab 3 in. thick, inner slab 3 in. thick and 3-in. cavity, the two 2-ft. 9-in. by 6-in. by 3-in. slabs joined together with two 3/16-in. galvanised iron diaphragms acting as ties and braces combined. The depth of diaphragms for 6-in. courses would be 3½ in. and the length 7 in., the ends entering the concrete to be split into four divisions, two pointing to each side at an angle of 120 degrees, and the end forks to point upwards and downwards in order to take a thorough grip in the concrete. The rybats and corners would be constructed in the same way, but these would be 12 in. deep and the diaphragms 7 in long and 6 in. deep. The ends of blocks forming ingoes would be thickened out to 5 in. as shown, and leaving 1 in. of a cavity at these points. Blocks shorter than 2 ft. 9 in. would have two diaphragms. The matrix for outer slab would be composed of 3 parts coarse river or pit sand free from coal particles to 1 part Portland cement, thoroughly mixed dry, thereafter water from a rose added (in the semi-wet process), the mixture to be close rammed into the moulds in thin layers and between the layers would be rammed closely 1-in. cubes of hard broken brick or ballast in the proportion of 4 parts, or 50 per cent. of the whole mixture. Care taken to fill all interstices and to keep the aggregate ½ in. back from outer face. The sand for outer slabs to be thoroughly washed in order to preserve the natural colour of the cement. The mixture for inner slab would be the same, except that the sand need not be washed and the matrix and aggregate would be mixed together. A similar mixture would be used for flue blocks. The 3-in. partitions would be composed of 4 parts breeze to pass a ¼-in. mesh, 1 part coarse sand, 1 part Portland cement, the joints and beds joggled. 4½-in. party walls would be the same mixture, but flat joints and beds. White cement would be used at the courses already referred to.

Builder.

General Specification.

	£	s.	d.
Remove vegetable soil from area 9 in. deep and deposit on garden plots, dig for founds and spread material under floors for filling up. 29 cu. yd. @ 1s. 3d.	1	16	3
Foundations in concrete, 5 parts broken brick or ballast, 1 part sand, 1 part Portland cement. 5⅑ cu. yd. @ 17s...	4	7	0
Fill up under all floors with hard dry material 6 in. deep and cover over with ¾-in. rough asphalte. 75 sq. yd. @ 1s. 6d.	5	12	6
Lay "Callendrite" damp-proof course to all walls. 15 sq. yd. @ 2s...	1	10	0
Build concrete blocks in 6-in. and 12-in. courses, 9 in. thick, bedded, and in lengths of about 2 ft. 9 in., bedded with mortar composed of 1½ parts river or pit sand, 1 part hydraulic lime, 1 part Portland cement, the outer face to be key drawn when being built and inner face struck flush; joints to be 3/16-in. 158 sq. yd. @ 6s.	47	8	0
Build 3-in. partitions in 12-in. courses and in slabs about 3 ft. long, bedded with mortar as before. 122¼ sq. yd. @ 2s. 4d.	14	5	3
Build 4½-in. party walls, blocks in sizes as for partitions, and bedded with mortar as above. 50 sq. yd. @ 3s. 6d.	8	15	0
Build concrete flue blocks having 3½-in. surround and 9-in. × 9-in. flues, in sizes about two and a half flues, and courses 12 in. deep with mortar as before, the flues not required for vents to be covered with slates at the necessary points. 13 cu. yd. @ £1	13	0	0
Build in kitchen jambs 4 ft. high and 3 ft. wide, jambs 18 in. × 6 in. and lintels 12 in. × 12 in., of concrete as for hollow blocks, and finished smooth. 2 sets @ £1	2	0	0
Extra for door and window lintels being reinforced with ½-in. bars, three bars to each lintel, and 1-in. × 1/16-in. stirrups, the lintels consisting of a 5-in. outer slab, having two bars and inner slab 3 in. thick with one bar, the two joined together with ¾-in. × 3/16-in. galvanised forked ties, two in the height and at 2-ft. centres. 81 ft. 6 in. lineal @ 6d.	2	0	9
Extra material in window sills and other projections. 3 cu. yd. @ £1	3	0	0
Build in two coppers with firebrick circled to suit and supply the necessary firebars and cast-iron door. Cope to be granolithic, equal parts granite chips and cement. 2 @ £1 8s.	2	16	0
Supply and build in two kitchen ranges. 2 @ £2	4	0	0
Supply and build in two hob grates. 2 @ £1 5s.	2	10	0
Supply and build in two mantel registers. 2 @ £1	2	0	0
Supply and build in two small mantel registers. 2 @ 12s. 6d.	1	5	0
Fit into concrete blocks at floor level 9-in. × 3-in. galvanised-iron ventilation gratings to ventilate cavity and under-ground floors. 10 @ 6d.	0	5	0
Total cost of Builder work	£116	10	9

Joiner.

	£	s.	d.
Roofing would consist of 6-in. × 2-in. rafters at 18-in. centres, covered with ⅞-in. half-checked sarking. 105⅛ sq. yd. @ 2s.	10	10	3
Ridges would be 8 in. by 1½ in. 62 lin. ft. @ 2¼d.	0	11	7½
Ceiling joists and oxter pieces, 4 in. × 2 in. 373½ lin. ft. @ 1¼d.	1	18	10
Wall-plates, 9-in. × 1-in. red pine. 66 lin. ft. @ 2d.	0	11	0
First floor joists would be 8-in. × 2-in. at 18-in. centres. 432 lin. ft. @ 4d.	7	4	0
2-in. × 1/16-in. hoop-iron wall plates. 99 lin. ft. @ ½d.	0	4	2
Sleeper joists to ground floor would be 2-in. × 2-in. narrow joists, laid on asphalte. 286 lin. ft. @ ¾d.	0	17	10
Wood flooring would be 4 in. × ⅞ in., tongued and grooved in the joints, well nailed. 100 sq. yd. @ 1s. 8d.	8	6	8
3/16-in. split lath on ceilings, camp ceilings and oxter pieces, broken banded. 146½ sq. yd. @ 6d.	3	13	3

	£	s.	d.
Door frames for inside partitions would be 3½ in. × 2 in., dressed and checked for doors, of white pine. Outside frames 4½ in. × 2 in. dressed and checked for doors, red pine. 362 lin. ft. @ 2d.	3	0	4
Facings to doors 3½ in. × ½ in., moulded on face. 540 lin. ft. @ 2d.	4	10	0
Skirtings, 4 in. × ½ in., moulded on edge. 334 lin. ft. @ 2½d.	3	9	7
Outside front doors would be 2 in. thick, divided into five panels, and stuck moulded on framing, back doors 2 in. thick, framed and lined, and made for glass on upper part. 75 sq. ft. @ 1s.	3	15	0
1½-in. pass doors, 4-panelled, and having planted mouldings on each face. 219 sq. ft. @ 11d.	10	0	9
Other doors to be of ⅞-in. matchwood, with three 6-in. × 1½-in. back bars moulded on edge. 109 sq. ft. @ 6d.	2	14	6
Window sashes to be 2 in. thick, divided as shown, and having ⅞-in. astragals-primed and glazed with 21-oz. sheet glass, the framing to be 4 in. × 2-in., double checked and rounded on arrises, the sills to be 6 in. × 3 in., double weathered, the ends set into check at bottom of ingoes, all hinged on side to open outwards, the sills to be grooved for 1½-in. × $\frac{3}{16}$-in. iron weather bars. 189 sq. ft. @ 1s.	9	9	0
Framing and sills, etc. 256 lin. ft. @ 2d.	2	2	8
11-in. × ⅞-in. shelving to be fitted up in pantry and scullery. 60 sq. ft. @ 3½d.	0	17	6
Stairs to be made with pitch pine, having 10½-in. × 1½-in. bottled treads, ⅞-in. risers, and 11-in. × 1½-in. stringers. 28 steps @ 5s.	7	0	0
Door furniture, 4 7-in. rim locks @ 3s. 6d.	0	14	0
Door furniture, 12 6-in. rim locks @ 3s.	1	16	0
Door furniture, 6 5-in. rim latches @ 2s. 6d.	0	15	0
6-in. steel hinges to doors, 22 pairs @ 8d.	0	14	8
Window furniture, 4-in. brass edge hinges, 26 pairs at 7d.	0	15	2
Iron casement stays, 26 pairs @ 1s.	1	6	0
Living-room to have two plain mantels and cabinets combined, made with ¾-in. plain plates, dooked to face of plaster walls, and small glass doors on upper part. 2 @ £1 5s.	2	10	0
Sink to have hardwood drainer properly fixed. 12 sq. ft. @ 3d.	0	3	0
Total cost of Joiner Work	£90	2	2

Slater.

	£	s.	d.
Roofs to be covered with blue "Eternit" diagonal slates in 11⅞-in. × 11⅞-in. sizes, firmly nailed and riveted together as per maker's specification. 115 sq. yd. @ 2s. 4d.	13	8	4
Cover roof boarding under slates with inodorous roofing felt. 115 sq. yd. @ 1½d.	0	14	4
Chimney cans. 10 @ 3s.	1	10	0
Point raggles and skews with mastic and oil. 100 lin. ft. @ 2d.	0	16	8
Total cost for Slater Work	£16	9	4

Plumber.

	£	s.	d.
Put 4-in. cast-iron beaded rhones at eaves of front and back roof slopes. 60 lin. ft. at 8d.	2	0	0
Drops and close ends. 12 @ 8d.	0	8	0
Cast-iron rain-water conductors to be 3-in. × $\frac{3}{16}$in. metal with broad faucets cast on back. 53 lin. ft. @ 9d.	1	19	9
3-in. offsets. 4 @ 2s.	0	8	0
5 lb. lead in flashings of chimney stalks, small gutters at eaves of gable-roof slopes, flanks, and piend rolls. 4 cwt. @ £1 7s.	5	8	0
Total for Plumber Work	£10	3	9

Plasterer.

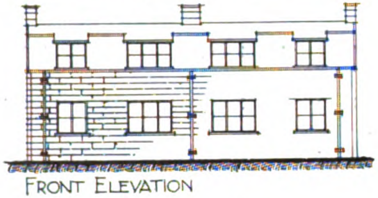
	£	s.	d.
3 coats plaster on ceilings and camp-ceilings, finished white and smooth. 146½ sq. yd. @ 7d.	4	5	6
Walls of apartments, excepting scullery, bathroom, fuel, and back lobby, to be finished with $\frac{3}{16}$-in. coat of plaster left white and smooth. 300 sq. yd. @ 4d.	5	0	0
4-in. concrete floors in scullery, bathroom, fuel, and lobby, finished with 1-in. granolithic, tinted red. 26 sq. yd. @ 3s. 3d.	4	4	6
4-in. concrete floors at front entrances, but lined into 4-in. squares and having 4-in. black border. 2½ sq. yd. @ 4s.	0	10	0
12-in. × 6-in. concrete steps at entrances finished with 1-in. granolithic. 12 lin. ft. @ 9d.	0	9	0
Bed and point windows with mastic and oil. 20 @ 1s.	1	0	0
Total for Plasterer Work	£15	9	0

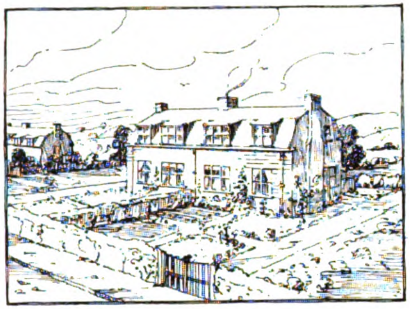
Fittings, &c.

	Prime cost, each		
	£	s.	d.
Kitchen range	1	12	0
Living-room fire	1	2	6
Large mantel register	0	18	0
Small mantel register	0	10	6
Outside door locks	0	2	9
Inside door locks	0	2	3
Latches	0	2	9
Iron casement stays	0	0	9
Casement handles	0	1	0

CONCRETE COTTAGE COMPETITION

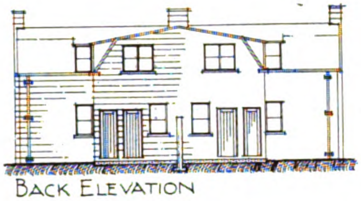
		Sup. Area	Height	Cub. Contᵗˢ
H.	10·0 × 2·9	27·6	8·6	233·9
P.	10·0 × 8·9	87·6	8·6	743·9
KP	14·6 × 11·0	152·6	8·6	1296·3
Sc	8·6 × 8·0	68·0	8·6	578·0
B.	14·6 × 11·0	140·0	8·0 Aver.	1120·0
B	12·0 × 10·0	120·0	8·0	960·0
B.	11·0 × 8·6	93·6	8·0	748·0
L.	6·8 : 2·9 4·6 : 2·3	27·4	8·6	232·4

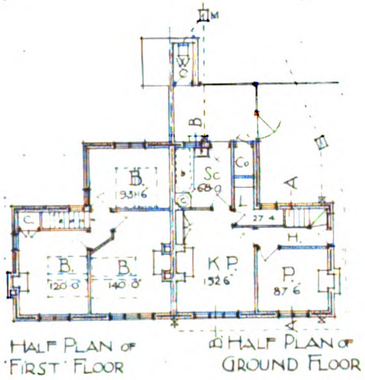

FRONT ELEVATION



CUBIC CONTENTS OF BUILDING
MEASURED FROM BOTTOM OF FOOTINGS
TO APEX OF ROOF

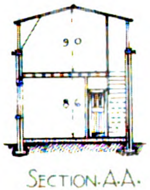
	CUBE FT
45·0 × 16·0 × 21·0 HIGH =	15120
24·3 × 8·3 × 21·0 =	4200
TOTAL CUBIC FEET	19320


BACK ELEVATION

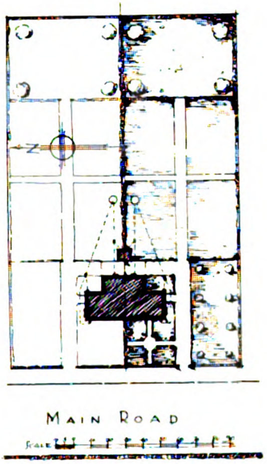


HALF PLAN OF FIRST FLOOR

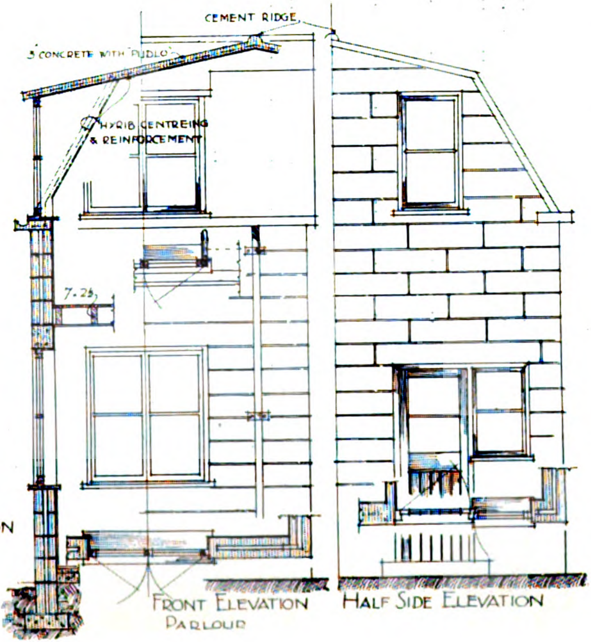
HALF PLAN OF GROUND FLOOR



SECTION A.A.



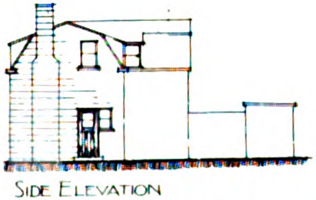
MAIN ROAD

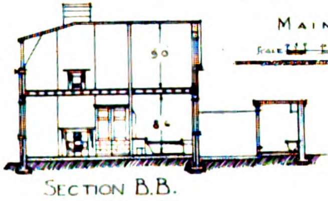


SECTION

FRONT ELEVATION PARLOUR

HALF SIDE ELEVATION


SIDE ELEVATION



SECTION B.B.

SCALE

DESIGN No. 195 .. BY W. G. DAVIES.

Cost, Data, &c.

The cost has been compiled and ascertained by actual measurement from the drawings, and in the case of outside wallings these have been measured (nett wall surface) all taken at 9 in. thick, including cavity, and all openings deducted. Projections added extra and priced separately per cubic yard of concrete. Galvanised iron diaphragms are taken at 12s. 6d. per cwt. The totals for two cottages work out as follows:

	£	s.	d.
Builder	116	10	9
Joiner	90	2	2
Slater	16	9	4
Plumber	10	3	9
Plasterer	15	9	0
Painter, say	10	0	0
	£258	15	0

This cost represents current prices and includes for builder's profits—deduct per Clause 1, builder's profits at, say, 8 per cent., the total becomes £238 3s. 2d.

It is assumed that a concrete block-making machine would be hired for making the blocks, and, allowing for hire and the cost of face plates the sum of £35. which sum spread over the six cottages represents £11 13s. 4d. per pair of cottages. Adding this to the last total, the prime cost to the owner when buying his own materials and employing labour would be for two cottages, £249 16s. 6d. Price per cottage, £124 18s. 3d.

Measuring the building as per Clause 12 of Conditions the cubic contents are 15,180 cub. ft. This works out at bare 4d. per cub. foot.

With Design No. 195. (By W. G. Davies, 94 Jesmond Avenue, Manningham, Bradford.)

Report.

THE design submitted is for semi-detached houses suitable for homes for labouring men in the West Riding of Yorkshire. The houses have been carefully planned to afford the greatest possible convenience and accommodation for the money spent. Due consideration has been given to the thoroughly hygienic conditions of family life in the arrangement of rooms and facilities for an improved state of living.

The entrance door is placed at the side, thus leaving the entire and pleasant west aspect of the house for the living rooms. Entrance is made into a small hall from which also the staircase to first floor leads Both the living room and parlour are directly entered from the hall.

The parlour is detached from that portion of the house allotted to working purposes.

The living room has been so planned, with doors in one corner, that it does not become a passage to another part of house. It is of convenient size, and is provided with kitchen range, and a china cupboard in recess.

A scullery, fitted with sink, copper and bath, the latter having hinged cover to serve as table, is easily accessible from living room and garden.

The pantry is large and light, and can be directly entered from living room and scullery.

A w.c. and a store house for coal are provided, both are entered from yard, but easily accessible from scullery.

Three bedrooms, each directly entered from landings, are provided on first floor, and are so planned that each may contain two single beds.

The adult bedroom is so placed as to intercept any communication between boys' and girls' rooms.

In girls' room a convenient cupboard is built over stair head.

Specification.

Strip soils from site to be built upon and stock same. Excavate for foundations. Cover the site with 4-in. concrete, composed of 6 of broken stone, and 1 of sand and 1 of Portland cement.

The walls to be built of hollow concrete blocks, size 32 in. by 9 in. by 9 in., made in a "Winget" concrete block machine. The concrete to be composed of 5 parts gravel, 1 part sand, 1 part best Portland cement. The mould to have a thin layer of sand in bottom to give rough-cast finish, and then 4 in. good solid gravel concrete and mould filled up with concrete of clean boiler ashes (proportioned as before), being cheaper than gravel, and also forms a better surface for skimming over with plaster, and prevents condensation on walls. The roof to be formed of 3 in. slab concrete, of 1 in. good ash concrete laid on centering first, then 2 in. gravel concrete graded and mixed 6 to 1, trowelled off smooth when partly set. Five per cent. of "Pudlo" waterproofing material to be mixed dry with gravel concrete. The centering and reinforcement to be of "Hy Rib" self-centering, No. 24 gauge. The "Hy Rib" sheets to be placed in position with lath surface downwards. Interlock all adjoining sheets at sides and ends by clinching of ribs and wiring. "Hy Rib" to be attached to 4-in. by 4-in steel tee irons at purlins, and ridge by clips and galvanised iron wire. Temporary stringers of 4-in. by 3-in. deal to be fixed between bearings of "Hy Rib" until concrete is set. Floors to be finished with 2-in. breeze concrete levelled to receive floor boards. The floors of scullery, pantry, coals, and w.c. to be of paving, 3 parts slag chippings to $\frac{3}{8}$-in. mesh to 1 Portland cement, trowelled smooth. All steps and thresholds to be finished as above. The chimneys to be formed of 16 in. by 16-in. by 9-in. flue blocks made in "Winget" machine.

Carpenter and Joiner.—All carpenters' and joiners' work to be in thirds Gefle deal.

Joists to first floor to be of 7 in. by 2½ in. covered with 1-in. T and G boarding.

Windows to be of 2½-in. rebated and chamfered Yorkshire standsheets, with 6-in. by 2½-in. sills, with 1¼-in. by ¼-in. iron water bars.

Frames grooved all round for plaster. Sashes hung with W.I. butts, and provided with casement openers.

Doors to be of 1⅞-in. framed and braced doors, filled in with 1-in. V.-jointed boarding, hung with 3-in. butts to 4½-in. by 3-in. rebated frames.

Plaster.—Lath plaster float, and set ceilings on ground floor.

The ceilings of first floor to be floated and set only.

Plaster on walls, two coats.

Walls of scullery and pantry to be limewashed only; skirtings to be 7-in. cement.

Painter.—All woodwork to be primed and painted three coats oils.

Walls to be coloured with Hall's distemper.

List of Fittings, &c.

	£	s.	d.
1 "Syrok" W.C., brown salt glazed, p.c.	0	18	0
1 salt-glazed fireclay sink, 30 in. × 18 in. × 5 in., p.c.	0	9	8
1 cast-iron enamelled bath, with brass cocks, p.c.	2	10	0
1 C.I. rustless washing copper, p.c.	0	18	0
3 C.I. mantel registers and grates, each, p.c.	1	8	0
1 kitchen range, p.c.	4	10	0

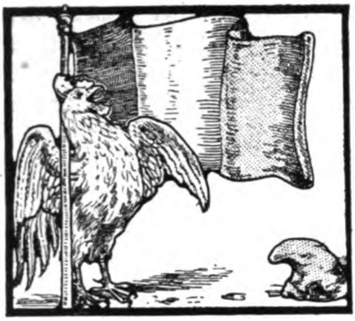
ESTIMATE.

The estimate of cost has been arrived at by two methods—viz., priced rough quantities, and by cubing. The figures given below are arrived at by cubing the building, measuring from the bottom of footings and to top of ridge.

Cube of Building.	cu. ft.
45 ft. × 16 ft. × 21 ft. high	15,120
24 ft. 3 in. × 8 ft. 3 in. × 21 ft. high	4,200
W.C.	
6 ft. × 7 ft. × 8 ft.	336
Total cubic feet for semi-detached	19,656

19,656 cu. ft. @ 3d. per cubic foot = £245 14s.

£122 17s. per cottage.



THE THÉATRE DES CHAMPS ÉLYSÉES, PARIS.

REINFORCED CONCRETE WORK.

By **ALBERT LAKEMAN, M.S.A.**

The following description is another instance of the excellent way in which reinforcea concrete can be used in theatre work, and it again shows that the material lends itself well to architectural treatment.—ED.

THE building here described affords an interesting example of the application of reinforced concrete to the construction of a theatre, the material being employed throughout for the weight-carrying members. It is an important building which exhibits much freedom and ingenuity on the part of the designer, M. Roger Bouvard, architect, 16, Place Vendôme, Paris, and there are many interesting points in the planning and equipment of what is essentially an up-to-date theatre. It has a frontage of about 130ft. to the Avenue de Montaigne and a depth of about 340 ft. On passing through the outer vestibule access is had to a large inner vestibule 80 ft. wide and 48 ft. deep, and from this the grand theatre is entered. The auditorium practically occupies a space equal to a square with a side of 120 ft. Inside the square the plan is arranged to give a circular space about 92 ft. diameter for the auditorium proper, and this contains three tiers of balconies, which are all carried on the cantilever principle, without any columns to obstruct the view of the spectators. A small comedy theatre is provided over the large vestibule at the first floor level, and the stage itself is 62 ft. deep, 130 ft. high, and 85 ft. wide, flanked on one side by a building used for offices and on the other by stores. The dressing-rooms are provided at the extreme rear of the building, and these open on to a large court, which is entered by a wide

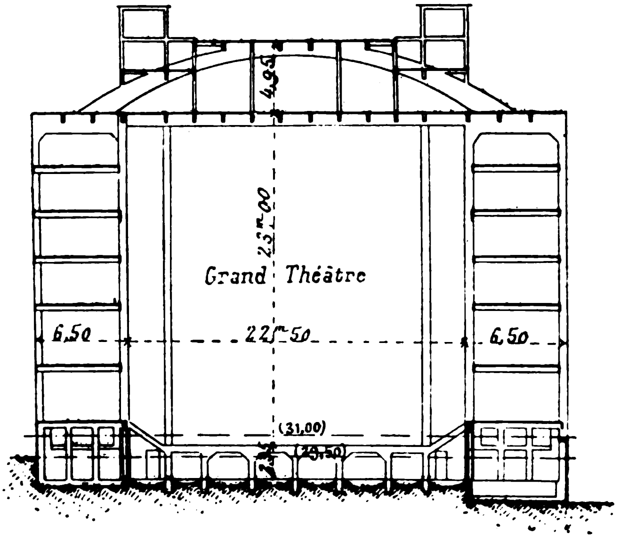


Fig. 1. Transverse Section.
THE THÉÂTRE DES CHAMPS ÉLYSÉES, PARIS.

passage running along the back of the stage. Various other spaces are allotted to rehearsal rooms, foyers, staircases, etc., and the total height from the floor under the stage to the roof is about 121 ft. The reinforced concrete work was designed by MM. A. and G. Perret, and as the whole structure is framed up in this material, it may be said that the whole of the decorative effect is governed by the construction as regards the main lines and features, and even in the elevations the constructional piers are allowed to form the main lines, and the enrichment is confined to the filling-in panels, and the marble facing is designed accordingly. A good general idea can be gathered of the framing from the skeleton illustrated in *Fig.* 2, where the construction is shown as stripped of its covering. A great depth was required under the stage, and this necessitated a very deep basement, while it was considered desirable to keep the ground floor as near the pavement level as possible. In consequence there was the question of water to be considered, as the basement floor is below the level of the neighbouring River Seine, and at various times of the year flooding is likely to occur when the river overflows its banks. The lower floors are therefore constructed in the form of a large dish, which forms the seating for the vertical divisions, which are watertight and act as stiffeners to the dish, they being carried up to the ground floor level. There is a considerable pressure on the foundations, especially under the stage and the electrical machinery, and concrete piles had to be driven at certain points, while in other cases the loads are distributed directly on to the soil. The piles are connected by large reinforced beams, and the plan illustrated in *Fig.* 3 shows these beams under the stage portion. They are spaced at intervals of about 6 ft. 9 in., and the

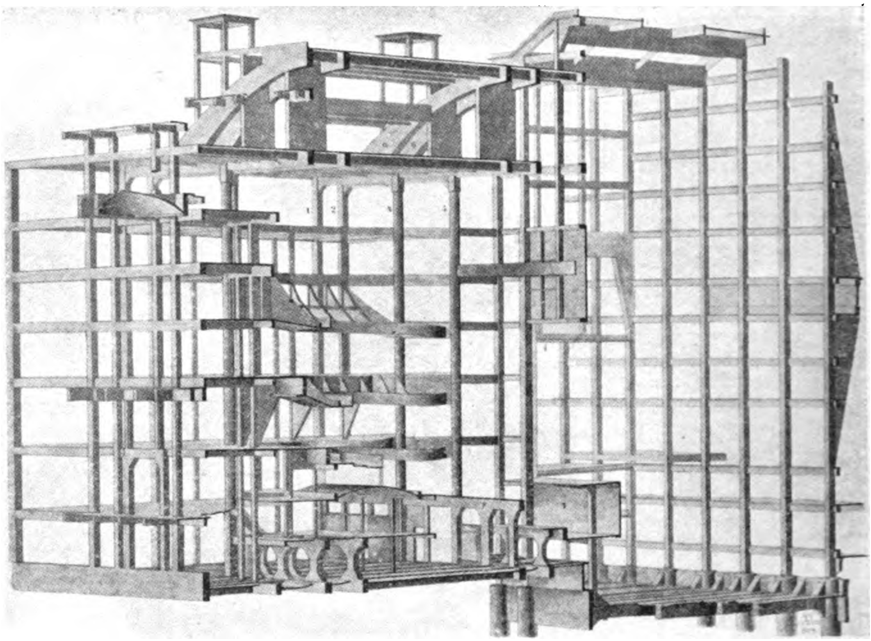


Fig. 2. Skeleton of Reinforced Concrete Work.
THE THÉÂTRE DES CHAMPS ÉLYSÉES, PARIS.

slabs between are curved with the concave surface above in order to better resist the upward pressure of the soil. These beams have varying spans up to 60 ft., and the maximum depth which occurs at the centre is about 4 ft. 9 in., this reducing towards the supports. The reinforcement consists of ten bars in the upper and ten in the lower surface, and the two sets are connected by numerous links or binding. Haunches are formed at the ends adjacent to the supports, and these are double, in some cases occurring both above and below the beams. The most interesting feature in the whole of the construction is that employed in connection with the auditorium. Here the loads are carried by what are practically two large reinforced concrete frames, each consisting of deep beams at the ground level and above the ceiling of the auditorium

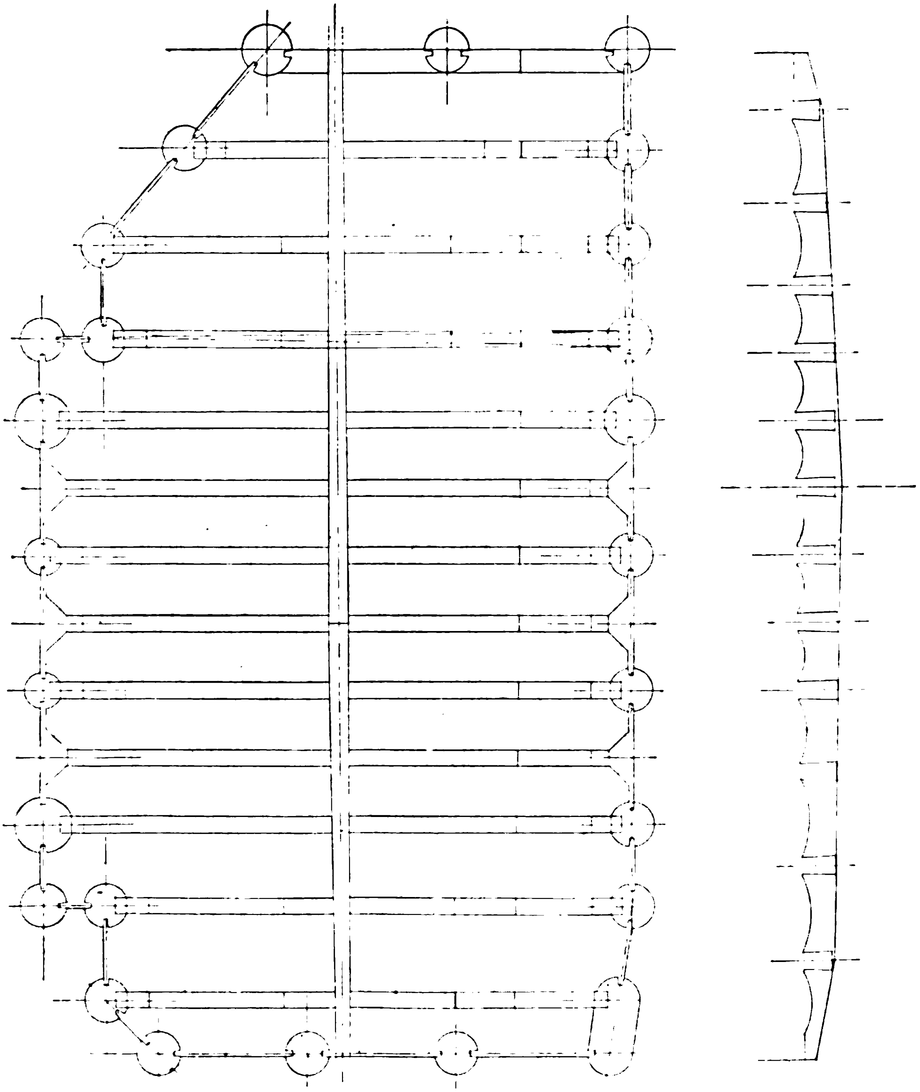


Fig. 3. Plan and Section of Foundation Beams under Stage.
The Théâtre des Champs Élysées, Paris.

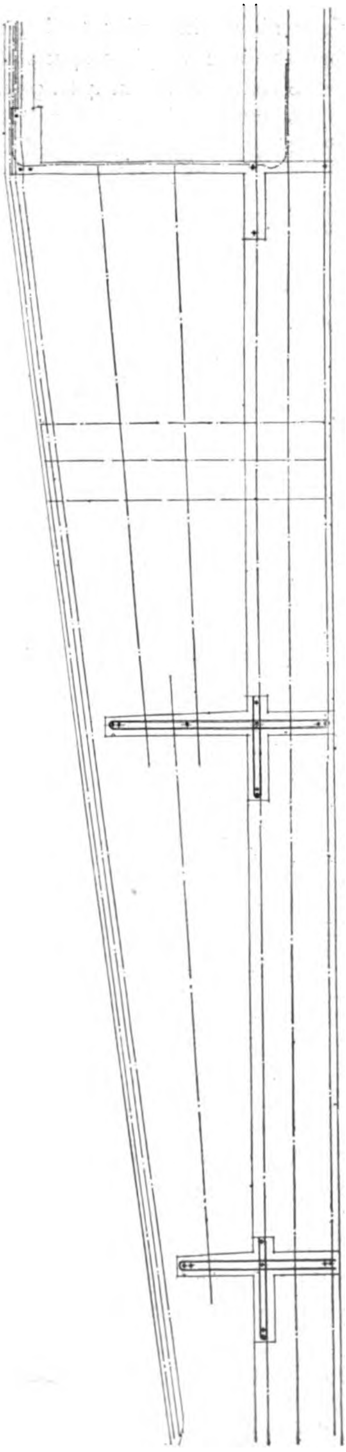
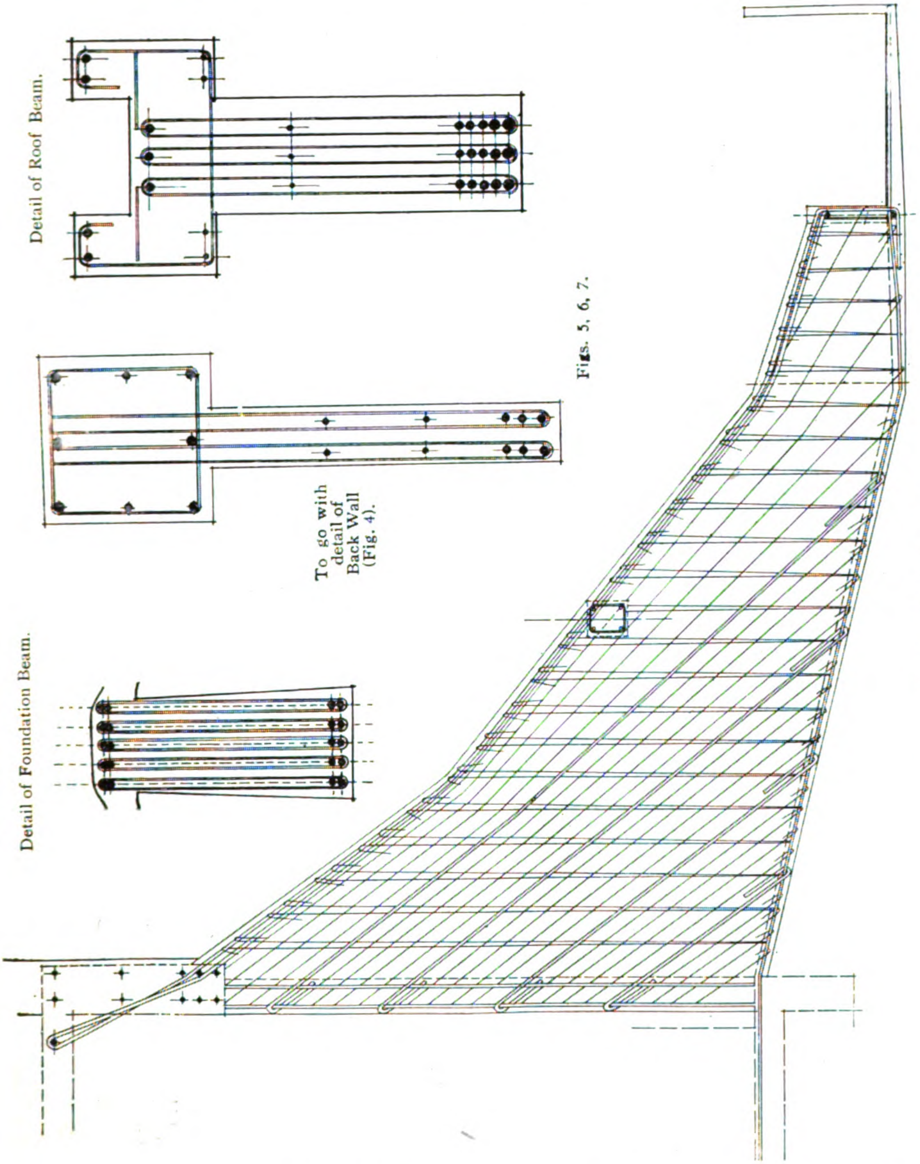


Fig. 4. Detail of Back Wall.
THE THÉÂTRE DES CHAMPS ÉLYSÉES, PARIS.

with connecting columns. The beams at the lower level are deep, open web beams, having two flanges connected by stiffeners at intervals, and these beams are in pairs with a curved connecting slab between at the soil level. The columns at the ends of the frames bear on these, there being four columns in a group at the side of each frame, two of these occurring as piers in the walls and the other two being formed as columns on the circumferential line at the back of the circles. All these are heavily reinforced, and the columns and piers are connected by large reinforced beams at the top which act as the bearing for two large arched reinforced beams in each frame, these arched beams being 95 ft. long. The upper part of the structure is suspended from these frames, and the whole design and construction is influenced by them. The idea of these frames with the arched beams at the top can be gathered from the drawing before mentioned as *Fig.* 2. It is a very ingenious and bold method of construction, and in spite of the large space occupied by the auditorium, it leaves it free and unobstructed; and yet the structure is rigid and the loads well distributed on the soil. The balconies are supported by large reinforced concrete cantilevers having a projection of 17 ft. to 20 ft., a typical example of which is illustrated in *Fig.* 8. These cantilevers are rather numerous, the main ones taking their bearing on the columns of the frame above mentioned, which occur on the outer circumference of the circles, and the intermediate ones are supported by secondary columns between. These cantilevers are heavily reinforced, the number of bars employed varying, of course, with the projection and position, but a general idea of the system employed can be gathered from the details illustrated. The columns in the vestibule are all constructional members of reinforced concrete arranged to form a colonnade, which is very effective. The floors of the theatre, foyers, and corridors are all constructed of reinforced concrete, the spans in many cases exceeding 20 ft., and the beams are generally allowed to project below the slabs to form panels, which remain as part of the decorative treatment. All the walls are constructed of reinforced concrete, these generally consisting of vertical columns and horizontal main beams, with the slab filling between, the latter in many cases consisting of brickwork, to


Detail of Roof Beam.
To go with detail of Back Wall (Fig. 4).
Detail of Foundation Beam.

Figs. 5, 6, 7.

Fig. 8. Detail of Balcony.
The Théâtre des Champs Élysées, Paris.

which white marble lining is attached as a facing. The wall at the back of the stage is 70 ft. long and 130 ft. high, and owing to the necessity for keeping a clear space immediately over the stage for the manipulation of the scenery, it was constructed independently of any intermediate beams or supports on to the other portions of the structure. It is constructed with vertical continuous piers having a width of 18 in. and eight lines of vertical reinforcement well tied with links. Horizontal beams are provided at twelve levels in the height, these being of reinforced concrete, and thus the whole becomes a large reinforced concrete frame with panels which are filled in with brickwork, the latter being in two $4\frac{1}{2}$-in. leaves with a 9-in. cavity between. A detail of a portion of this work is illustrated in *Fig.* 4, which shows the method of construction at one point where it was necessary to form the apartment outside the stage space half way up the height. This back wall supports the roof over the stage, this being constructed with three large main beams, each 3 ft. 3 in. deep and having a span of about 60 ft. These beams support the flat roof slabs, in which large openings are formed for the roof lights, which are constructed with combustible material, thus ensuring their destruction in case of fire on the stage, and allowing the smoke and flame to issue at this point and lessening the danger of the fire spreading to the auditorium. The main roof over the

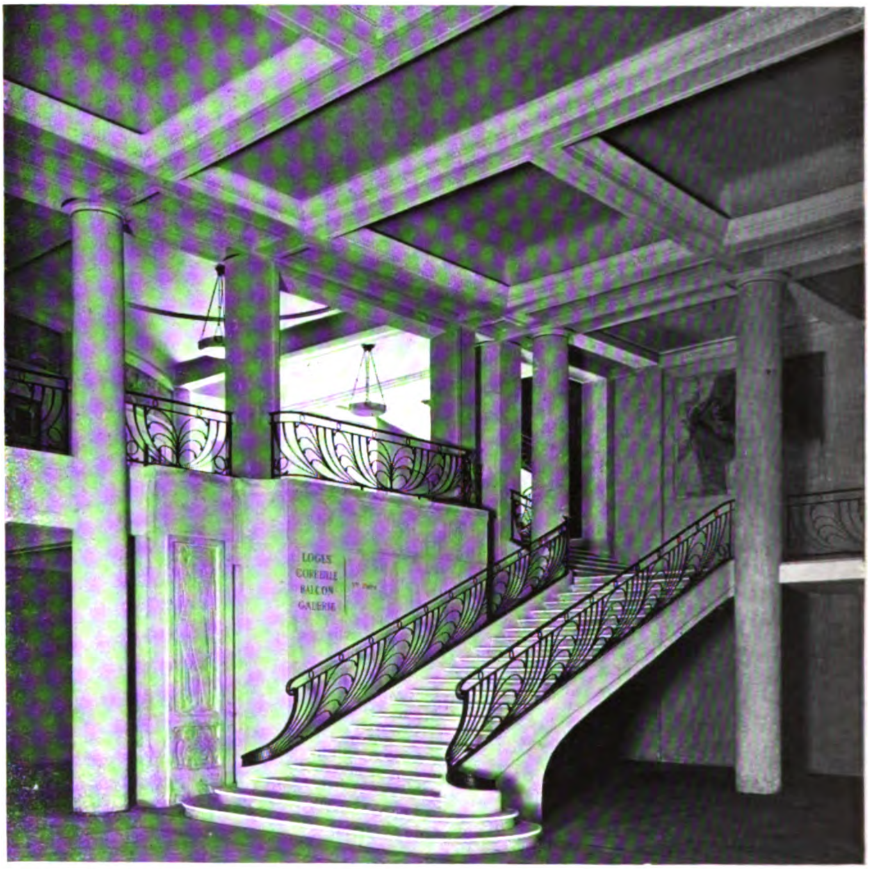


Fig. 9. Reinforced Concrete Staircase and Columns.
THE THÉÂTRE DES CHAMPS ÉLYSÉES, PARIS.

rehearsal floor, situated above the auditorium, is constructed with sufficient strength to allow of its use as a terrace, and a large number of persons can be accommodated thereon. The main beams here span between the arched beams over the two frames previously mentioned; thus the spans are considerable. The opening between the stage and the auditorium is 40 ft. by 35 ft., and the clear space above the opening on the stage side is 83 ft., which allows the scenery to rise up out of the view of the audience without rolling or folding. The space under the stage is 27 ft. deep, and the stage floor has an inclination towards the auditorium of about 1 in 33. This floor has sliding and movable portions which can be arranged to act separately or together, and these allow the whole of the rear portion to disappear or rise up automatically, while sliding traps are provided to completely cover the whole space. The accommodation in the orchestra is sufficient for 110 performers, and this space can be completely covered if required. An organ has been installed above the orchestra, and this is operated by electricity and controlled from the stage. The large auditorium is chiefly lighted by a large circular shell in the ceiling, having a diameter of 50 ft., and which forms a feature in the ceiling decoration. This shell is composed of crystal filling in a framework of small bronze bars, and some of the lamps are placed on the edge of the shell to indirectly light the auditorium while casting a strong light on the painted frieze,

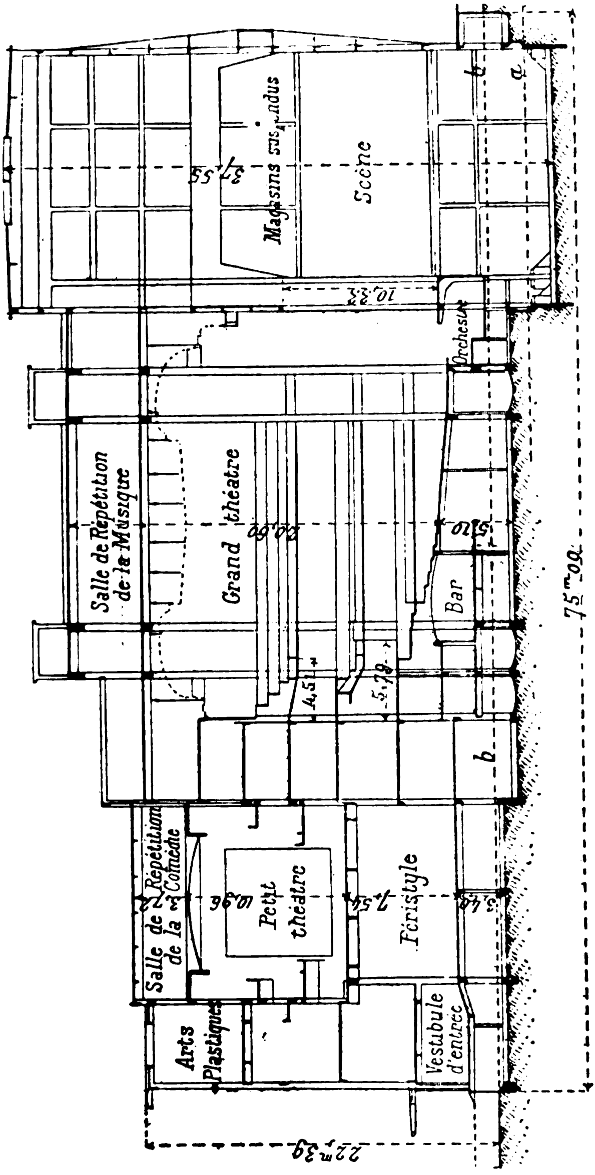


Fig. 10. Longitudinal Section.
The Théâtre des Champs Élysées, Paris.

which is an important factor in the decorative treatment. The lighting of the stage is arranged with a main switchboard, from which every possible variation of colour and light can be controlled, and the heating and ventilation has been considered and designed to give the maximum comfort to the audience. No less than five large boilers are installed, and the whole of the air is filtered and heated if required, while extracts are provided for the withdrawal of the vitiated air at two levels. The fire prevention apparatus is very complete, and a portion of this is on the automatic principle, and the cleaning is executed with a powerful vacuum plant.

The planning and equipment are such that the building may be said to be the most up-to-date example of a theatre in the world, and no effort has been spared to render it convenient and comfortable for both audience and staff. The extensive use of reinforced concrete has given the greatest satisfaction to all those connected with the design and construction, and the straightforward manner in which the material has been employed, by making the constructional members part of the decorative scheme, satisfies the senses as giving an excellent example of what may be termed honest construction. The building reflects great credit on the designers, who have been fully awake to the possibilities of the material which has been used, and the building has benefited thereby; while it should serve as a model to those responsible for the design of important structures in the future.

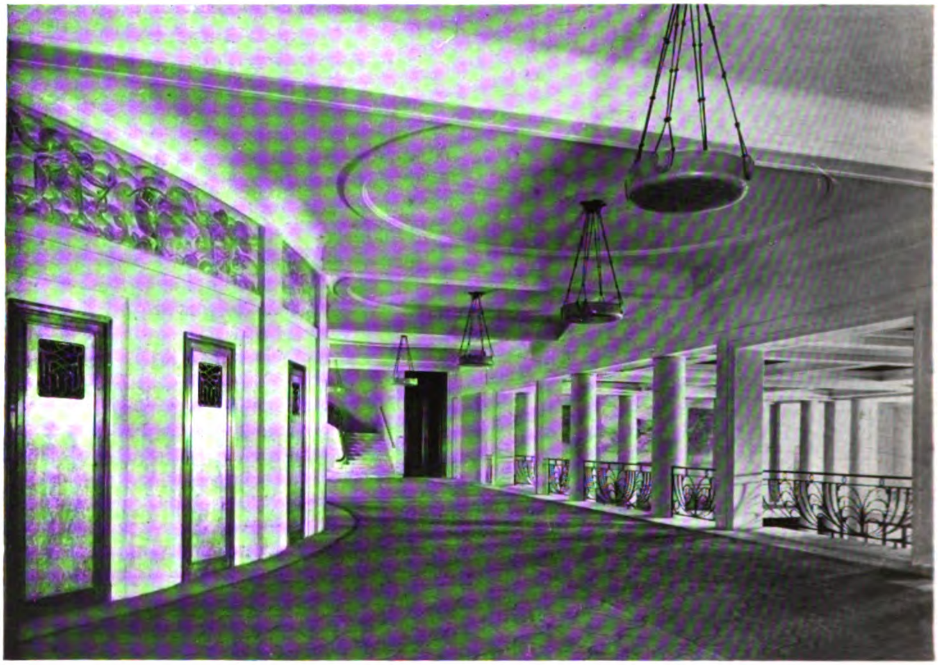
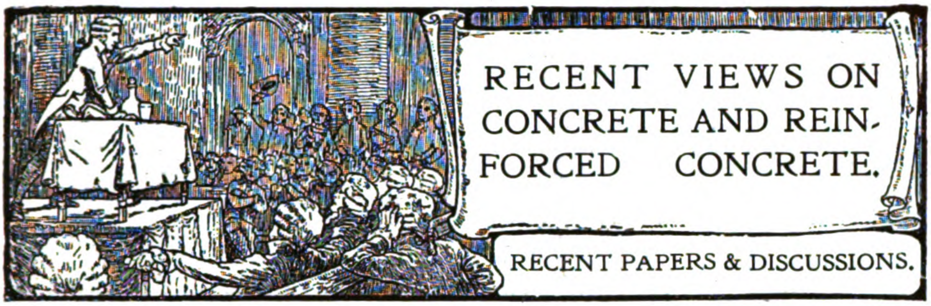


Fig. 11. Interior view showing treatment.
THE THÉÂTRE DES CHAMPS ÉLYSÉES, PARIS.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

RECENT PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE NATIONAL CONFERENCE OF CONCRETE ROAD BUILDING.

FINISHING AND CURING CONCRETE ROAD SURFACES.

The following is a further report presented at the recent National Conference of Concrete Road Building held in Chicago, and it may not be without interest at a time when much attention and study is being given to this question. This Report was drawn up by a Committee comprising Mr. F. E. Turneaure, Chairman (Dean, College of Engineering, University of Wisconsin, Madison, Wisconsin), Mr. H. J. Kuelling (President, Wisconsin Highway Commissioners' Association), and Mr. E. D. Boyer (Engineer, The Atlas Portland Cement Co.).

No attempt has been made to formulate specific recommendations or specifications, but an endeavour has been made to analyse the subject and present the salient features in a manner which may form a basis of discussion and future consideration.

In finishing and curing a concrete pavement the operations may be considered in three parts:

1. The securing of a surface which shall, in general, have the desired grade and cross-section.
2. Finishing the surface so as to secure the desired degree of smoothness.
3. Curing of the concrete so as to produce as hard and dense a material as is reasonably practicable.

Securing the Correct Grade and Cross-Section.—The question of accurate grade and cross-section is of considerable importance in producing a surface which will be free from undesirable irregularities. Small irregularities give unsatisfactory conditions for traffic at high speed, such as automobile traffic, while large irregularities give rise to depressions and pockets likely to hold water and become icy and also lead to unequal wear. To secure good results, grade stakes should be accurately set, and where side strips serve as grade lines, they should be set with care and be straight and true. The tendency of modern practice in the construction of hard road surfaces is to reduce the crown of the road to a minimum. If the results are to be satisfactory under these conditions, increased accuracy in grade and cross-section will be necessary.

Narrow roadways are usually brought to grade and line by striking off the fresh concrete by means of a board, cut to conform to the desired shape of the road, and resting at its ends on longitudinal strips laid to grade. Where care is used in setting these strips and manipulating the board, accurate results are secured. In the case of wide roadways and city streets grade points must be established at frequent intervals in order to secure the desired accuracy. There is much poor work along this line to be seen on many of our city streets, even where asphalt surface is employed. Much more care should be used on this part of the work than is the practice at many places.

Finishing of Surface.—The method of finishing the surface of the concrete after it is brought to line and grade is a matter of considerable importance, although the wear of traffic will soon eliminate small differences in the degree of smoothness secured. One of the principal objects to be attained in the surface finishing, after the concrete is struck off, is to secure a surface layer which will be as uniform in character as practicable, and free from voids and other irregularities. The securing of a good dense and even surface is dependent, to a considerable extent, on the care with which the concrete has been shovelled and stirred into place. Uniform and careful workmanship in this part of the process is important. Concrete which has an excess of large stones at one point and an excess of mortar at another point will not wear uniformly, and cannot be made uniform in the finishing process.

A common practice is to finish the surface by means of a wooden float manipulated from a bridge. Good results can be, and have been, obtained also by the use of the shovel alone. To secure a surface which is uniformly somewhat rough, the use of a coarse broom is common and is to be commended, although a short period of wear will eliminate any differences due to brooming.

To secure additional roughness, especially on grades, grooves have often been made in the concrete. Results of such grooving have been variously reported, some reports being satisfactory, while others show unsatisfactory results due to the rapid wearing of the concrete and the disappearance of the grooves. It is evident that to accomplish any very lasting result the grooves must be fairly deep and not spaced too closely. A diagonal rather than a transverse system appears to be an advantage, but is not so easy to construct. Longitudinal grooves are of very doubtful value.

Where the experience with grooves has been satisfactory, it appears that the surface layer of concrete has been of rather superior quality and made of fine aggregate. This would appear to be a reasonable condition, and from observation of some of the members of the committee, as well as from various reports, a grooved surface made in rich, high-grade material will show a very satisfactory durability. Grooves would hardly appear to be advisable in connection with a coarse aggregate.

Curing. — The curing of the exposed surface of the concrete is one of the most important parts in the entire process. Good concrete can easily be spoiled by a too rapid drying out, and under the conditions frequently met with such a result may easily follow, unless great care is taken to protect it. Laboratory tests of concrete cured under different conditions show that it is easy to increase the strength 50 per cent. by a proper treatment over what may be secured under improper conditions. It appears, also, that the effect of rapid drying is even greater on the hardness of a concrete surface and on its permeability than on its crushing strength. Concrete allowed to harden without proper curing shows a soft surface which can readily be scratched. It is, at the same time, much more porous than properly cured material, and will show greater deterioration from frost action. The length of time during which concrete will continue to absorb water in chemical combination is much greater than is generally supposed. While the hardening process continues quite slowly after the lapse of a month, it is also true that with a continued supply of water increase in strength beyond that time will be very considerable. The critical time in securing a good instead of a bad result is included, perhaps, in the first week; but for best practical results a week is often too short.

The essential thing is, of course, to keep the concrete wet a sufficient length of time to secure the best results consistent with the expense involved and the improvement which will result. In hot summer weather it may be considered as absolutely necessary that this process shall be continued for at least seven days. A number of specifications require fourteen days, and a longer time is occasionally demanded. A mere sprinkling once a day in hot, sunny weather is certain to be very ineffective. When it is remembered that the actual evaporation from a free water surface during hot, dry weather is as great as $\frac{1}{4}$ in. per day, it is obvious that a single daily sprinkling, with no protection against evaporation, is very inadequate. To prevent evaporation, an excellent and common practice is to cover the surface as soon as practicable with a layer of earth. This serves to reduce the evaporation very greatly, and would seem to be almost necessary under high summer temperatures. The concrete thus covered should be sprinkled frequently enough to keep the surface in a moist condition. For the first twenty-four hours after laying, or until the surface can be safely covered with earth, a canvas covering on hot, windy days is advantageous and is used by some engineers. Traffic should be kept off at least three weeks and longer when possible, especially late in the season, when the temperatures are relatively low.

As a matter of some value, your committee has made a search through recent engineering literature on the subject assigned to it. The results of this search may be briefly summarised as follows:

Out of twenty-one reports of actual construction and seven specifications and papers on this subject, the method of finishing was reported as follows: Fifteen finished by means of a float, four by means of troweling. Thirteen broomed the surface.

In the matter of curing, three reported as using canvas, eight as using sand and earth; four reported 7 days as the period of sprinkling, two 14 days, and one 21 days.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

THE NEW GOVERNMENT SHIP LOCK IN BLACK ROCK HARBOUR.

THE accompanying drawing and illustration (*Figs.* 1 and 2) show the new Government ship lock in Black Rock Harbour in Niagara River, Buffalo, N.Y., and the cofferdam used in its construction, the section of the steel sheet piling utilised being noted in drawing *Fig* 3. 6,500 tons of sheet steel and 73,500 cu. yds. of concrete were used for the cofferdam and walls at a cost of 4.37 dollars per cu. yd. There are in service two steel guard gates and three steel lock gates, also eight cable gate-operating machines. Six culvert valves were used, together with four electric capstans, the latter being seen in the illustrations, *Figs.* 4 and 5, of the completed ship lock, its gate and equipment.

The lock chamber is 650 ft. long by 70 ft. wide and the cofferdam is 947 ft. long by 260 ft. wide (outside measurement). Lackawanna steel sheet piling was used in the construction of the cofferdam. This form of sheet piling is a rolled section with a flexible joint, and has a positive and double interlock made with three metal to metal points of contact, and it is stated to be watertight and to result in economy of space.

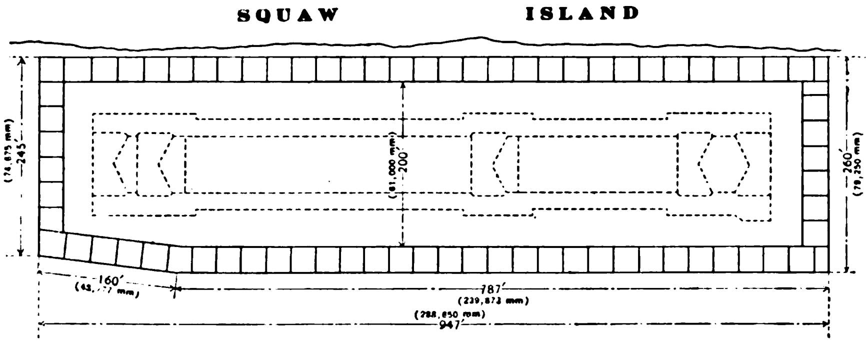


Fig. 1. Plan of Reinforced Concrete Cofferdam.
NEW GOVERNMENT SHIP LOCK IN BLACK ROCK HARBOUR, U.S.A.

It is said to be more easily driven by reason of its balanced section, and each piece is interchangeable and can be withdrawn and redriven; while there are no bolts, rivets or structural shapes to loosen or shear off in handling, shipping or driving.

The lock gates include an upper guard gate and upper lock gate, also an intermediate gate as well as a lower lock gate and a lower guard gate. Each gate consists of two leaves, the upper and lower guard gates being alike, and the upper, intermediate and lower lock gates are alike.

The structural steel for one leaf for the upper and lower guard gates was estimated at 113,000 lb., and of the upper, intermediate and lower lock gates 138,000 lb. The total for the ten leaves of the five gates was 1,280,000 lb., with cast steel of 86,500 lb. The lock gate operating machinery was covered in the specifications by two methods, one of which was by submerged steel cables leading over sheaves to be placed on the I-beam supports in the sheave chambers and wells in the concrete lock walls to electric winding drum machines; the other method was by steel spars above water fitted to the gates and installed with electric operating machines in the recesses in the concrete lock walls.

For the cable gates, the cable machines include one for each leaf of the upper guard gate and of the upper, intermediate and lower lock gates, four right-handed and four left-handed—eight in all consisting of a spirally grooved winding drum driven by gearing receiving power from an electric motor mounted in the recesses in the lock walls.

The drum was grooved for $\frac{3}{4}$-in. cable, and motor power was required for a maximum pull on the gate cable of 8,000 lb. at a speed of 35 ft. per minute. The electric motors are of the 25-cycle 3-phase 440 volt wound rotor type, operating at about 360 r.p.m., and have drum type of reversing controller and resistance for continuous operation. Each machine has a circuit switch or device for automatically and reliably cutting off the electric current from the motor at a point in and near the end of both the opening and closing swings of the gate leaf, to prevent slamming of the leaf against the gate recess or mitre sill.

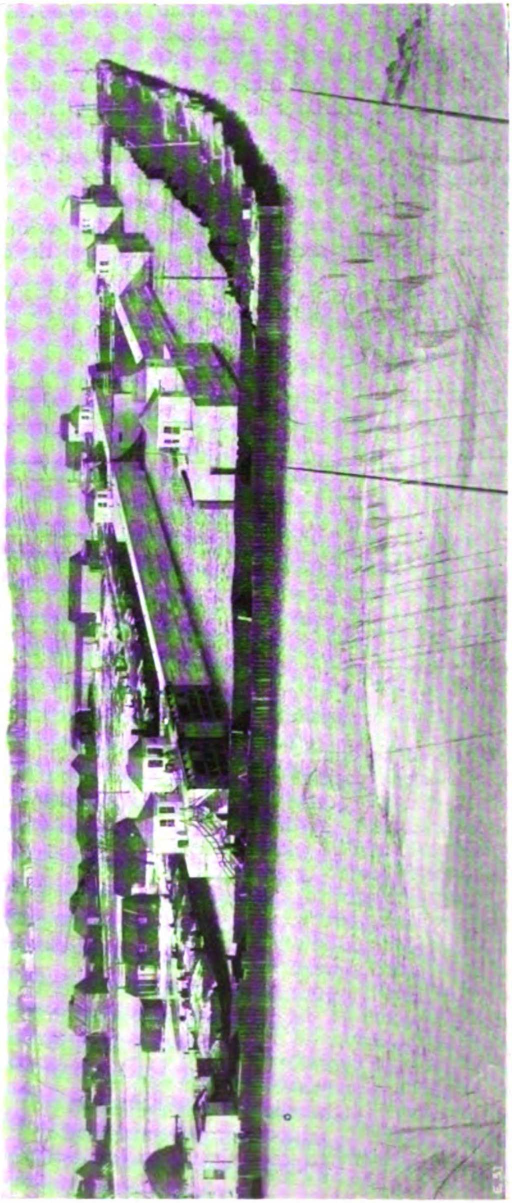


Fig. 2. View showing Reinforced Concrete Cofferdam.
NEW GOVERNMENT SHIP LOCK IN BLACK ROCK HARBOUR, U.S.A.

The gate machine and motor are mounted on a base about 9 ft. by 6¼ ft. The cables for the swinging lock gates are of flexible plow steel grade, ¾ in. diameter, with six strands, 19 wires to the strand, on hemp centre, capable of sustaining a tensile stress of 50,000 lb.

It is of interest to note that the pumps for pumping out the lock chamber are vertical shaft submerged centrifugal pumps, one of 20-in. and one of 12-in. diameter discharge, installed in the pump well with discharge pipes and connected by shafts to electric motors at the top of the wells.

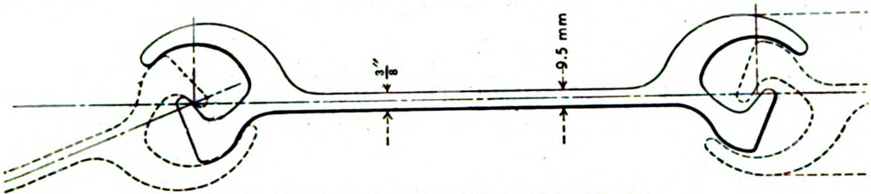


Fig. 3. Section of Steel Sheet Piling used in Cofferdam.
New Government Ship Lock in Black Rock Harbour, U.S.A.

The specifications called for pumps with a combined capacity for discharging from the lock chamber 8,000,000 galls. of water in 10 hours against a head increasing from approximately 4 ft. (when the lock chamber is full) to 29 ft. (when the lock chamber is pumped out 1 ft. below mitre sill level), running at safe speeds with an economical expenditure of power under the varying conditions.

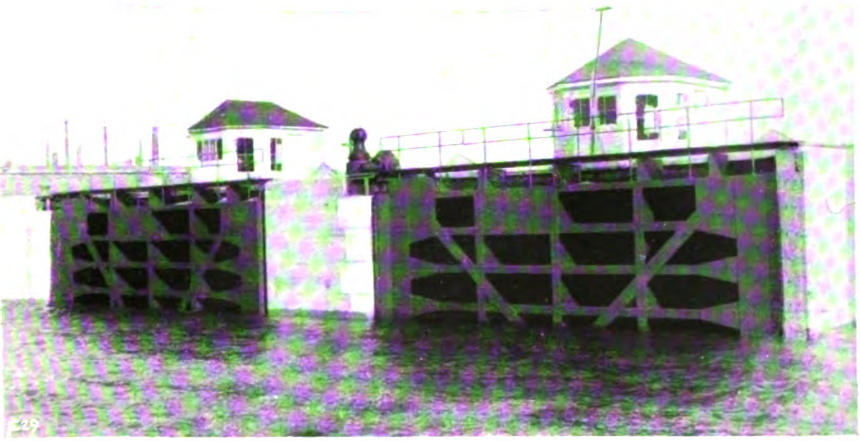


Fig. 4. Electric Capstans and Gates.
New Government Ship Lock in Black Rock Harbour, U.S.A.

The larger pump has an average capacity of 10,000 galls. per minute and the smaller one of 3,500 galls. per minute. The electric motors are required to furnish the necessary motive power efficiently and economically without overload.

The electric capstans have a diameter of barrel at throat of 12 in. to 13 in., with a length of barrel of about 24 in. The capstan head is provided with single and double hand bar power, geared with the shaft to the electric motor to give a pull of not less than 10,000 lb. at a speed of not less than 25 ft. or more than 30 ft. per minute. The capstan and motor are mounted on a base anchored in the concrete.

THE HARRISBURG REINFORCED CONCRETE PROTECTIVE WALL.

The Board of Public Works of the City of Harrisburg, Pa., has recently constructed a reinforced concrete step protective wall for the intercepting sewer along the Susquehanna River, as shown in the accompanying illustration. This construction consisted of about 13,200 linear ft. of stepped concrete protective wall with steel reinforcement, together with the necessary appurtenances, excavations and embankments.

The base of the footwall and of all stringers rests on solid rock. All sand, earth, gravel, boulders where the footwall and bottom of stringers are located were removed and the surface of the rock cleaned ready to receive the concrete. At first a section of the embankment was built to approximate line and grade.

After placing and compacting a section of the embankment to approximate line and grade, the excavations were made at the locations of the stringers, the rock cleaned and the stringers constructed. After the construction of the stringers the excavation was made for the footwall. This was built in 8-ft. alternate sections, with expansion joints, and in the construction of the steps themselves the concrete was poured in alternate 8-ft. sections, with expansion joints. Finally, 13,000 ft. of concrete sidewalk were built in alternate squares. It was necessary to exercise great care in removing trees or other vegetation occurring along the line of the work, and only such trees and vegetation as actually came within the lines of the excavations or construction were removed.

The concrete sidewalk was laid 14 ft. wide in square blocks, 1 : 2½ : 4½ concrete being used for the base with wearing surface 1 in. thick. The thickness of the sidewalk is 6 in. and the concrete for the base was laid fairly dry, in alternate blocks, and thoroughly rammed. The mortar for the wearing surface was mixed in the proportion of 1 part cement to 1½ parts sand, fairly dry, and after spreading to the proper thickness upon the concrete base was thoroughly tamped and then struck off with a straight edge to a uniform surface. The top coat was placed upon the concrete base as soon as possible after the concrete was in place and before the concrete had begun to set, so as to become thoroughly bonded with it. The top coat, after having been brought to the correct elevation and surface, was trowelled down hard and smooth with a metal trowel and then marked on the surface with a grooved roller.

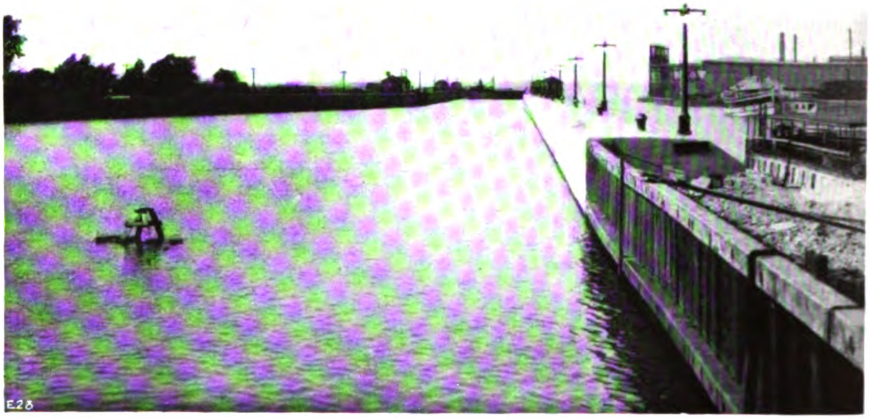
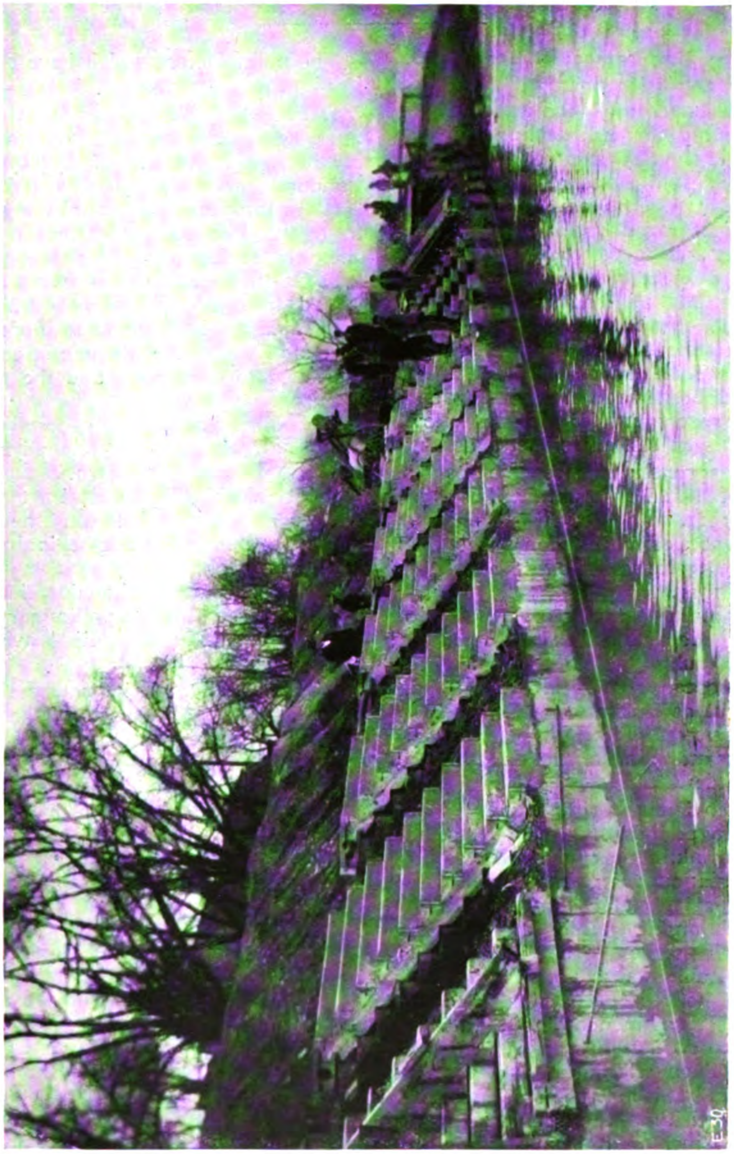


Fig. 5. View of Ship Lock.

NEW GOVERNMENT SHIP LOCK IN BLACK ROCK HARBOUR, U.S.A.

The steps of the protective wall were also given a surface coat similar to that above mentioned, which was applied in the same manner. After being worked to an approximately true surface the block markings were made directly over the joints in the base with a tool so as to cut clear through to the base and completely separate the wearing courses of adjacent blocks.

Every second block has an expansion joint ¼ in. thick fitted with strips of tarred paper. The surface edges were rounded to a radius of ½ in., and when partially set the surface was trowelled smooth. The steel bars embedded in the concrete work are of mild open-hearth steel having an ultimate tensile strength of 55,000 lb. to 65,000 lb. per sq. in. before deformation and an elastic limit of not less than one-half the ultimate strength, and showing an elongation of 25 per cent. in 8 in.



Reinforced Concrete Protective Wall at Harrisburg, U.S.A.

In placing the rods in the work the greatest care was taken to compact the concrete closely around and against the bars, and all bars were perfectly cleaned of all dirt, grease, scale and other foreign matter before placing them in the forms and care was taken to keep them in this condition until the concrete was placed. The lapping of the ends of the steel bars was about twenty-five times the diameter of the rod used. The concrete was mixed with a gasoline power-driven concrete mixer.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Training and Employment of Boys in the Building Trades of London.

A report has recently been issued by the London County Council, dealing with the training and employment of boys in the building trades in London, submitting a report by Mr. J. C. Smail, Organiser of Trade Schools for Boys, and many interesting facts and figures are given therein. The whole subject of apprenticeship and training for the building trades has received much consideration from time to time, but it cannot be said that any material advance in the adoption of systematic methods has been made in the last twenty years. The report puts forward the following proposals as calling for settlement:

1. The apprenticeship scheme of the Institute of Builders, submitted on 7th February, 1911.
2. The report of the London Association of Master Decorators, submitted on 20th December, 1911.
3. The proposals for the reorganisation of the building department in the Northern Polytechnic, submitted 11th March, 1912.
4. The proposed scheme for a building trades school at Hammersmith.
5. The suggested formation of consultative committees in connection with the building trades.

There is no doubt that the building trade is subject to periods of great depression, and is, in addition, much affected by seasonal variations; and these facts render it more difficult to arrive at any solution on the question of training and employment which prevent the many calls upon charitable organisations by the workers. The report contains so many figures and recommendations that it is impossible to deal with even a small percentage of them without giving a great deal of space, but it may be mentioned that it is proposed that the scholarships at Brixton be increased from twenty to thirty, that the ten at Hackney be made tenable at the Northern Polytechnic, and fifteen additional scholarships be granted there, and that when the school at Hammersmith is opened thirty scholarships annually should be allocated there.

The main factors which have been kept in view are:—

1. The building trades provide, and must necessarily continue to provide, one of the main avenues of employment in London.
2. An insufficient number of boys drawn from the London population at present enter the building trades.
3. Of the actual entry, many are precluded from beginning their training at a suitable age owing to the modern conditions of work, the attitude of employers and men to beginners, and the physique required.
4. The impossibility generally of a thorough training being secured in workshops in London is known.
5. The desirability of at least partially bridging the gap between the school-leaving age and the trade-beginning age is generally recognised.
6. It is the duty of the education authority to provide suitable preliminary education for definitely recognised avenues cf employment.

The report certainly indicates a thorough investigation of all aspects of the subject, and numerous graphs are given to illustrate the numbers employed in the various trades at all ages, and these are instructive and interesting.

"The Making of Highroads." By Alfred Edward Carey, M.Inst.C.E.

London: Crosby, Lockwood & Son, 7 Stationers' Hall Court, Ludgate Hill, E.C. 84 pp. + x.

Contents.—Roman Road Construction—Mechanical Road Traction—Essentials of Good Roads—Road Foundations and Surfacing—Modern Road Conditions—Bridges and Culverts—Various Pavings—Bituminous Concrete—Experimental Road Surfacing—Road Board Research—Reinforcing Foundations—Strategic Roads, etc.

This handbook is based upon a lecture delivered at the School of Military Engineering, Chatham, by the author, and the design of the work is to furnish a terse statement of present-day problems. There has been no attempt to deal with the details of the adjuncts which are now more or less standardised, but rather to put forward the essential points of the construction and upkeep of roads under modern requirements. The question of efficient road construction is one which has assumed tremendous importance, and it is necessary for all those connected with the work to study the subject in a thorough manner. The author deals with the making of highroads in a very interesting manner, and although some of the matter is superfluous as scarcely dealing with the main points of technical interest, its inclusion can well be excused on account of the way in which it is introduced. In the notes on the essentials of good roads, the author mentions that Mr. Wakelam, Surveyor of the County of Middlesex, recently estimated that to strengthen rural main roads sufficiently to carry heavy motor-car traffic would involve an expenditure of £80,000,000; that the district roads, outside the main roads, would similarly cost £184,000,000, and that the district roads in urban districts would cost £22,000,000. These figures are sufficiently large to cause the average reader to realise the importance of the subject under consideration at the outset.

The notes cover the theoretical and practical design of roads, and the question of surfacing from the aspect of wearing properties and dust avoidance is considered at some length. Many experimental roads have been laid down from time to time in various parts of the country, and the results are given by the author in order that a comparison may be made.

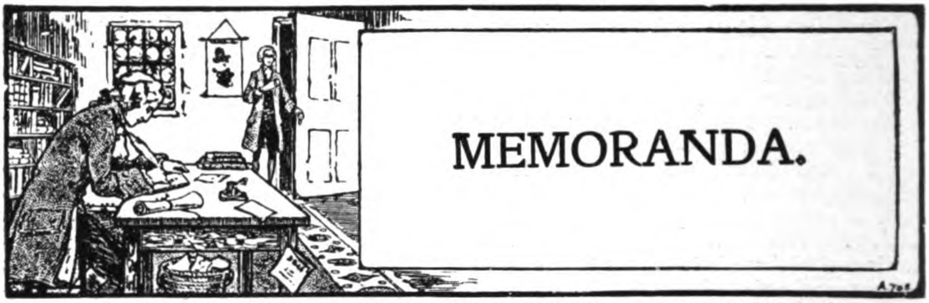
It is interesting to note that the author advocates the use of reinforced concrete for the road bed as probably the best material that can be employed. He considers that this material complies with the scientific requirements of a good road bed, as it is resilient, strong and easily manipulated. In these remarks we quite agree with the writer, and consider that the uses of this material for road construction have not been developed to anything like the extent they should have been.

Several appendices are added to the text, and the book is well worthy of recommendation as a concise treatise on road construction.

Reinforced Concrete Construction. Theory and Practice. (*La Construction en Béton Armé. Theorie et Pratique.*) By A. V. Magny.

Paris and Liége, Ch. Béranger. 1914.

This is a comprehensive text-book of nearly 600 pages, with very numerous figures, plates and tables. It is essentially a compilation, and its general features resemble closely those of other works of the same class. Simple methods of computation are employed, and the excellent printing and clear diagrams make the theoretical chapters very convenient for the student. The most important classes of structures are considered in order and illustrated by detailed drawings of actual buildings or engineering works. The principal official (French) circulars are reproduced in full. The general impression produced by an examination of the work is favourable. It is not easy for a new text-book of reinforced concrete construction to present any very original characters, and it is sufficient if the general principles are clearly and concisely set forth and the selected examples are interesting in themselves and are described with sufficient attention to the important points. These conditions are fulfilled in the present case, and the result is a handsome and convenient handbook. As a minor point, it may be mentioned that English and German proper names are very frequently mis-spelled.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Westminster Technical Institute.—The prospectus and time-table of the above Institute has now been issued for the session 1914-15, and we publish herewith particulars of the syllabus of the classes for Reinforced Concrete. The class for Structural Design in Reinforced Concrete is held on Wednesday evenings from 6.30 to 8.45. It is an advanced course with practice in design for civil engineers and others already well grounded in the theory of structural design, and the syllabus comprises:—

Physical properties and tests of concrete and steel; fundamental principle of combined action of concrete and steel; principal thories and formulæ for reinforced concrete beams; effect of fixity and continuity of ends; slab formulæ; T beams; double reinforcement; reinforcement with large sections; shear stresses in reinforced concrete beams and reinforcement therefor; reinforced concrete columns; combined axial thrust and bending stresses; graphical treatment of reinforced concrete beams; calculations for retaining walls; calculations for arches with and without hinges.

There is also a class on Friday evenings from 7.15 to 9.30.

This course is arranged to meet the needs of engineers, architects, district surveyors and students. The theory and construction of all formulæ are clearly explained without the use of higher mathematics; a large number of diagrams have been prepared by means of which the formulæ can be used without calculation, and practical examples of design will be fully worked out during each lecture.

Arrangements have been made for making and testing large experimental beams and members, and for testing cements, aggregates and test cubes of concrete.

Visits to works in progress will be arranged.

Syllabus.—Stresses in dissimilar materials acting in conjunction to resist stress; design of flitched beams and shaped beams in wood and steel; construction of standard formulæ by means of simple equations; moulds and false work, fireproofing and waterproofing; design of reinforced concrete beams, T beams, floors and slabs; shear; deflection; design of columns, walls and retaining walls; design of arches, domes, silos, water tanks and special constructions.

Full particulars as to admission to the Institution and classes can be obtained on application to the Principal, Mr. J. Stuart Ker, B.Sc., A.M.Inst.C.E., Vincent Square, Rochester Row, S.W.

Northern Polytechnic Institute.—The winter session 1914-15 opened at the end of last month. In the Department for Architecture, Surveying and Building the subject of Reinforced Concrete is very fully dealt with, and classes are held throughout the week, every evening from 7.30 to 9.30 (Saturdays excepted). The questions dealt with are graphic statics; reinforced concrete design (advanced); design of steel and reinforced concrete structures (advanced); strength of material and mechanics of structures; mechanics; structural engineering; practical mathematics; building; drawing; laboratory testing. The fee varies from 10s. to 15s. for a course. The classes are under Mr. R. Graham Keevil. Applications and inquiries should be addressed to the Secretary of the Institute at Holloway, N.

The Special Fire Service Force.—The Special Fire Service Force organised by the British Fire Prevention Committee, has been duly inaugurated with a nucleus of 300 fire surveyors, fire brigade officers, patrol inspectors and firemen.

Fire survey parties can be despatched for fire survey, pulling down and dangerous structure work at short call; a number of fire patrols, comprising skilled patrol men, can be put on either night work or permanent watches; and several complete fire service sections, comprising fire brigade officers and firemen with equipment complete, can be immediately mobilised as the necessity arises, to take up regular duty wherever requisitioned by public departments or other authorities requiring assistance in the national interest.

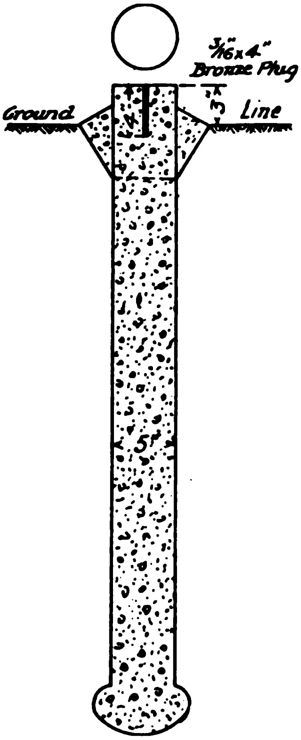
The direction and inspection of units is conducted by a small Headquarters Committee, of which the Earl of Londesborough is chairman.

The fire surveyors and principal fire brigade officers are rendering gratuitous service, whilst the inspectors, foremen, firemen, patrolmen and clerks receive a moderate honorarium when on service.

Besides organising the Special Fire Service Force, the British Fire Prevention Committee has been acting as a clearing house for all manner of queries from public authorities, etc., in the matter of special safeguards arising out of the state of war.

All applications to render personal service, and all inquiries should be addressed in writing to the Registrar, the British Fire Prevention Committee, 8, Waterloo Place, London, S.W.

A Concrete Survey Monument.—The accompanying sketch shows a concrete survey monument which has been used with considerable success in Southern Louisiana. It is built of cement mortar in a form made of common 5-in. iron stove pipe. The sand and cement are mixed dry, two parts sand and one part Portland cement, packed in cement sacks, each sack holding 0·75 cu. ft., and carried into the field. Two sacks are required to make one monument. Two lengths of stove pipe are placed in the hole. The mortar is mixed moderately thick; in marshy ground a rammer is used to crowd out a small amount of mortar at the bottom to form a spread base. After the whole is back-filled with carefully tamped earth, the remaining mortar is deposited around the top of the monument as shown. A 3/16 by 4 in. bronze bolt is pushed into the soft mortar flush with the top of the monument. The pipe is left in the ground.



The advantages of this type of survey marker are permanence, easy construction by ordinary labourers, easy transportation of materials, readiness with which materials may be secured and their cheapness; the pipe forms are the cheapest grade of black iron stove pipe, which comes "nested" in convenient shape.

Iron pipes have been extensively used for markers, but even galvanised iron rusts very rapidly, this destruction being most pronounced at the ground surface. Black iron pipe could not be depended upon in such locations to last for more than two or three years. The monument here illustrated was devised by Mr. Arthur M. Shaw, of New Orleans, U.S.A.—*Engineering News.*

CORRESPONDENCE.

In our issue of September last it was erroneously stated on page 597, in the article entitled "Rural Housing," that an "American" concrete-block-making machine was used. We have received the following letter in correction of this statement, and we also express our regret for the mistake.

To the Editorial Secretary.

Dear Sir,—We regret to find that, through inadvertence, the manufacture of the blocks for the cottages lately erected here was stated in the article that appeared in your Journal for September to have been done by an American concrete-block-making machine, whereas the credit should have been given to the Winget Concrete Machine Co., whose machine was used with such satisfactory results.

We should be much obliged if you would kindly make this rectification in your next issue.

Yours faithfully,
(Signed) Wm. Cubitt & Co. (Branch).

258, Gray's Inn Road, W.C.

TRADE NOTICES.

We have received the following letter :—

To the Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

"BRITISH MADE."

DEAR SIR,—We should be obliged if you will kindly state that our Patent Steel Piling and other specialities are, and always have been, entirely made in Great Britain, and therefore that some foreign steel piling material, which we are informed has been stopped from time to time by H.M. Commissioners of Customs for non-compliance with the requirements of the Merchandise Marks Act, Paragraph 7 :

> "All qualifying statements or indications must be distinct, in equally conspicuous and indelible characters with, and in close proximity to, the marks they are intended to qualify,"

was not ours.

We supply guaranteed British rollings only, and it is of importance to the public and rolling mills of the country, as well as to ourselves, that this should be known and fully realised.

We are, dear Sir, yours faithfully,

THE SIDE GROOVE STEEL PILING SUPPLY CO., LTD.

Forged Steel Crushing Balls.—These balls are extensively used by cement makers and manufacturers of cement making machinery, as well as by mining companies. The greatest part of the trade for these balls has up to the present gone to Germany. At a time when we are making a vast effort not only to keep our trade going, but to capture the trade which formerly went to our foreign competitor, we would specially direct the attention of those concerned that Messrs. James W. Carr and Co., Ltd., of Sheffield, are prepared to quote special terms for the best forged steel crushing balls, and are prepared to do their utmost to maintain deliveries. Full particulars regarding prices, etc., can be obtained from Messrs. James W. Carr and Co., Ltd., Speedwell Steel Works, Soho Street, Sheffield.

THE
VICTORIA
CONCRETE MIXER

1. Centre Ring Construction.
2. External Discharge Chute.
3. Drum ¼ in. Steel Plate.

The VICTORIA is designed for fast and efficient mixing. It will mix concrete faster than you can get rid of it.

The VICTORIA
is built to last
WRITE FOR CATALOGUE No. 29.

THE
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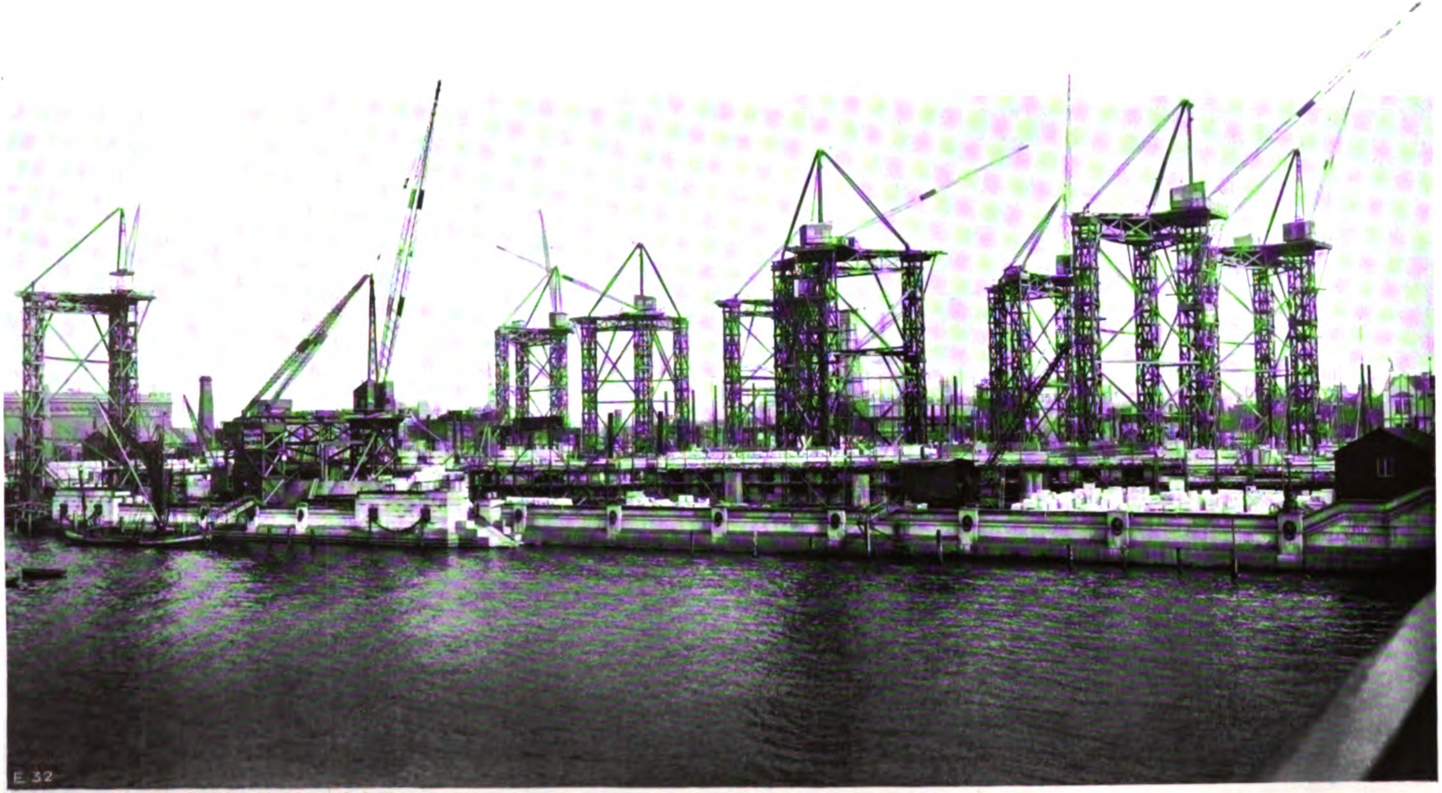


Photograph by Ernest Milner, Wandsworth, S.W.

General View of Site.
THE NEW COUNTY HALL.
(For description see page 653.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume IX., No. 11. LONDON, NOVEMBER, 1914.

EDITORIAL NOTES.

REBUILDING.

IT is still quite impossible to make any surmise as to the date of the termination of the war, but it is not too early to consider how the enormous quantity of rebuilding which will inevitably have to be done can be carried out.

In many ways the effect of modern shell fire can be best compared to the damage done by earthquake—there are undoubtedly many up-to-date Messinas on the Continent—but in an area subject to earthquake it naturally follows that rebuilding is undertaken in such a manner as to successfully combat any further destruction from the same cause. But the rebuilding which will be undertaken on the Continent at the end of the present war will not have to be of a kind to withstand either the war of Nature or the bombardment of heavy artillery, but will be a rebuilding of the house beautiful—a re-creation of cities, with their attendant great industrial works, bridges, railway stations, docks, warehouses, and factories.

Rebuilding on such a scale as is inevitable will naturally have to be economical; some form of construction in which stability, fire resistance, utility, and architectural pretensions combine will be a necessity A new need will arise—such a need as the present generation of workers has never before been called upon to meet—and there is little doubt that reinforced concrete, in all its wonderful adaptability, will be the material chosen for the plain, industrial, and utilitarian buildings, as well as those of a more ambitious character.

We are publishing in this issue an article dealing with the ornamental possibilities of reinforced concrete, and the description of the great statues which were so successfully erected on a public building on the other side of the Atlantic shows what fine decorative work can be evolved out of this material.

Unfortunately the decorative aspect of concrete and reinforced concrete does not seem to have been developed in this country, and it is to be regretted that for examples we have almost invariably to go to the United States. We hope in coming issues to publish descriptions and illustrations of how concrete can be used with *bonâ fide* architectural pretensions, which should be of interest to many of our readers.

THE TIMBER QUESTION.

THE question of the shortage of timber is likely to become a serious one, and the longer the war is protracted, the greater will be the shortage, and until the war is long past no return to anything like the normal peace supply can possibly be expected.

In this country, where the best Portland cement is so easily obtainable, the lack of timber can be well met by the use of concrete and reinforced concrete. In various issues we have illustrated and described numberless instances of the suitability of concrete for small wants for which timber has so long been used, and it is quite unnecessary to recapitulate them. We should only like to remind those who have hitherto been backward in recognising the use of concrete for small needs, usually met by timber, to try it boldly now that they are hampered by the shortage of their accustomed material, and we have no doubt that the life and staying power of concrete will be found factors not to be lightly disregarded.

CONCRETE FOR ROADS.

Road-making is another subject to which we shall have to turn our attention when the rebuilding of the destroyed towns is becoming an accomplished fact.

Reinforced concrete appears to be largely used in America for this purpose, but we have up to the present been able to obtain information regarding only one example in Great Britain. This we described and illustrated in our August issue. It has proved to be a conspicuous success, and there appears to us to be no reason, now that a successful start has been made, why this material should not be largely utilised in the near future. With the heavy motor traffic and the great steam lorries and pantechnicons that are now such familiar objects on our roads, the question of repair becomes a very serious matter, and a road which combines strength, hard-wearing properties, and resiliency is a desideratum. Any additional initial cost in the laying of a reinforced concrete road would be amply repaid by the saving in upkeep, while from a sanitary point of view its advantage is obvious.

THE USE OF CONCRETE IN THE SUBSTRUCTURE OF THE NEW COUNTY HALL.

This article deals with the substructure of this important building, and at a later date we hope to give some details regarding the superstructure, when the work is more advanced.

We would mention here that we are indebted to the London County Council for their courtesy in permitting us to reproduce the "Plan of the Principal Floor" (p. 660) taken from a publication issued by them on the occasion of the laying of the foundation-stone of the new Hall.—ED.

THE new County Hall now being erected for the London County Council is one of the most important buildings, if not the most important, designed and commenced in London for many years, and as such the methods employed in the construction of the various parts will naturally be studied with interest.

The building will serve a valuable purpose in bringing all the departments of the Council to one centre, and all those connected with the building industry who have occasion to consult with the officers of the Council will welcome the time when they can attend at the new Hall with the certainty that the required department is at hand, and that the wandering from one scattered department to another in various buildings and streets is no longer necessary. Only those who have actually experienced the inconvenience caused by the present state can fully realise the great advantages of the new building. The scheme in hand is a very big undertaking, and it will be remembered that a competition was held among architects, as a result of which Mr. Ralph Knott was selected to design and supervise the work, and Mr. W. E. Riley, F.R.I.B.A., the superintending architect to the London County Council, was appointed as consulting architect to act in conjunction with Mr. Knott.

The site, which is on the Surrey side of the River Thames adjacent to Westminster Bridge, has an approximate area of 6½ acres, and this was acquired at a total cost of £600,000. Some valuable work has been done in the reclamation of about 2 acres of foreshore along the river frontage. This work necessitated the formation of a pile dam constructed with timber piles 14 in. square against which the front of the embankment wall foundation abuts. This embankment wall will have a total length of 800 ft. when completed, and of this about 588 ft. have been constructed at the present time. It forms a continuation of the existing embankment fronting St. Thomas's Hospital, to which it is similar as regards architectural treatment. A variation is provided by the central pylons and steps down to the water level which were designed by Mr. Knott.

The construction of the wall was carried out under the direction of Sir Maurice Fitzmaurice, C.M.G., the late Chief Engineer to the Council, and the material used was plain concrete composed of six parts of aggregate and one

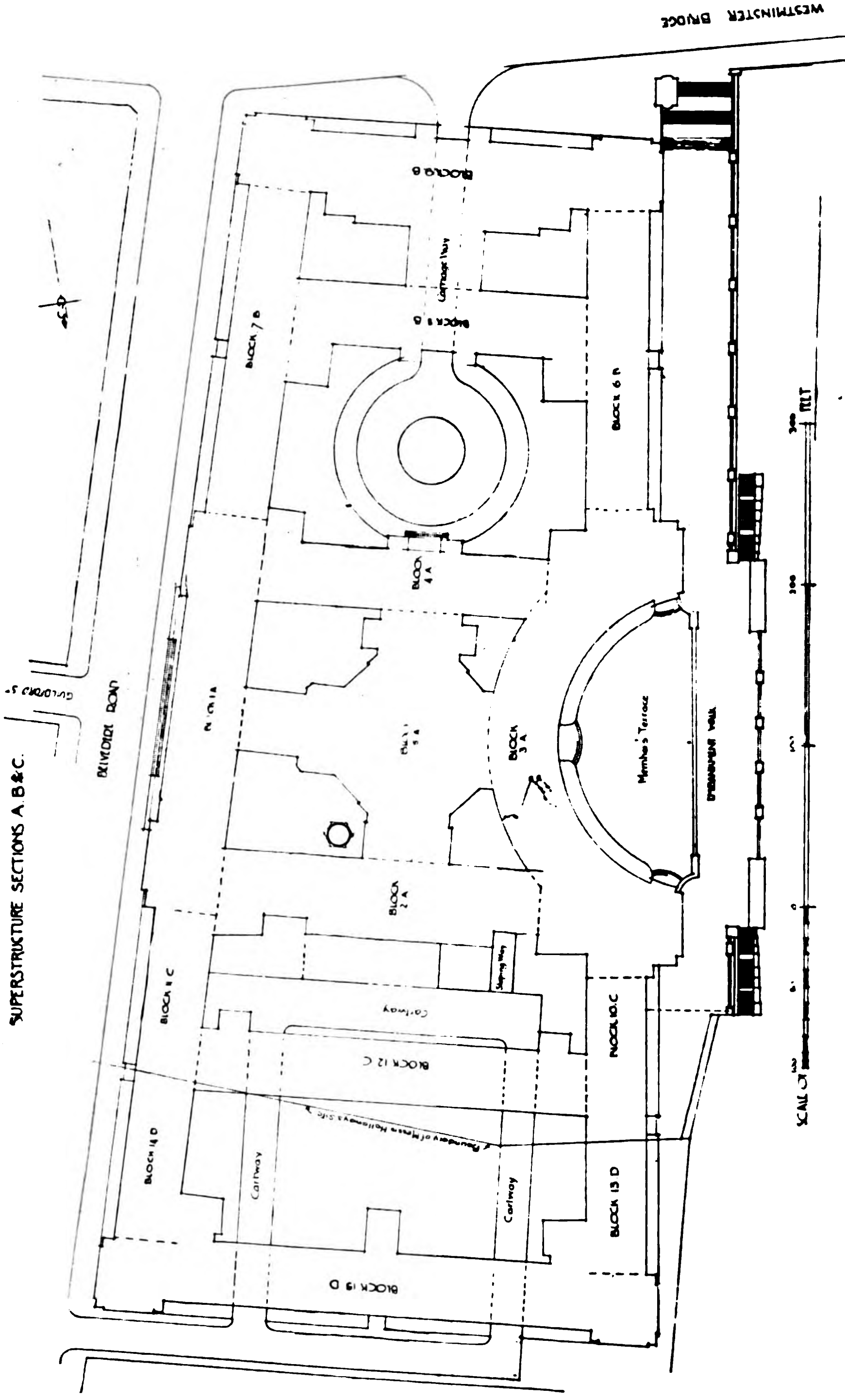


Fig. 1. Block Plan.
The New County Hall.

part Portland cement, this being faced with grey granite and having bronze enrichments and lamps similar to the existing embankment above mentioned. The section of the wall is illustrated in *Fig.* 4, and it will be seen to be of considerable thickness. The foundations are carried down to a depth of 35 ft. 6 in. below Trinity high water level, this depth taking into consideration the proposals which have been made for deepening the bed of the river below Westminster Bridge. The wall has a thickness of about 11 ft. at the level of the vault floor adjoining, and the width of the foundation is about 20 ft.

A large mass of concrete is formed as the foundation, this being about 11 ft. deep, and above this the wall is constructed with a slightly curved battering face to the river and two offsets, each of 2 ft. on the inside face, these offsets occurring at heights of 6 ft. Behind the wall a series of concrete vaults are constructed, and these will support the embankment roadway and the outer part of the Members' terrace above.

Owing to the large area occupied by the building, it has been divided into four distinct sections for contrast purposes—viz., Section A, B, C and D; and these are again divided into blocks, which have been numbered. Thus section A is divided into five blocks, B into four blocks, C into three blocks, and D into three blocks, giving a total of fifteen blocks in all.

Of these, the section A which occurs on the axial line drawn through the longer frontages is probably the most important, as this contains the council chamber and chairmen's rooms, together with committee rooms and various other important departments; and the outline of the plan with the curved façade to block 3 is a feature which will considerably affect the architectural treatment of the building. Practically the whole of the space covered by section D is at present occupied by Messrs. Holloway's building works, and this portion will form the last to be executed, following the extension of the river wall.

The frontages are approximately 750 ft. to the river and the Belvedere Road, 262 ft. to Westminster Bridge Road, and 350 ft. on the north side, and the building generally consists of two floors below the ground floor and six floors above this, giving a total height from the lowest floor level to the ridge of about 128 ft. The fifth and sixth floors are, generally speaking, formed in the sloping roof, which is very high, but owing to the large frontages the building will not strike the onlooker as being a high one.

The sub-basement and basement floors are devoted chiefly to storage rooms with wide corridors, and in the sub-basement trolley lines are provided to all these corridors for easy transit of goods from one department to another. In addition to these stores, spaces are allocated to the boiler-house, coal bunkers, pump room, ventilating plant, electrical plant, staff lavatories, staff club room, and rifle ranges. A cartway from the Belvedere Road is formed at the northern end of the building, and this occupies a great deal of space. It is interesting to note that the only room to be treated architecturally on these two lower floors is the muniment room, which occurs on the basement of section B, and this will be finished with panelling executed in plaster.

The foundations of the building may be said to be constructed on the most simple lines, these consisting of a plain concrete raft over the whole site upon which the structure is erected. Upon investigating the nature of the soil, it was found to consist of about 12 ft. of made ground, 7 ft. of Thames mud, and 13 ft. of ballast under which occurs the London clay. The depths required did not necessitate passing through the ballast, and consequently the raft was formed on the top of this.

This raft consists of five 12-in. layers of concrete, giving a total thickness of 5 ft. over the entire area of the site, the first layer being formed 1 ft. in thickness, on which is laid a damp course, after which an additional 4 ft. was added, making the total thickness, as stated, 5 ft. The concrete was mixed in the same proportions as those employed for the embankment wall. A damp course consisting of one part Portland cement and two parts sand is laid between the first and second layers, and this damp course is carried through the surrounding retaining walls and up the outside faces of same. The surrounding retaining walls around the whole site are also constructed with plain concrete, and they commence at practically the same level as the raft, the latter being carried through beneath the walls with a slight increase in thickness on the underside. The retaining wall--when eventually completed by the construction of the wall at the northern end and connected up to the wall which forms the enclosure on the western boundary--will eventually seal off the site from any possible influx

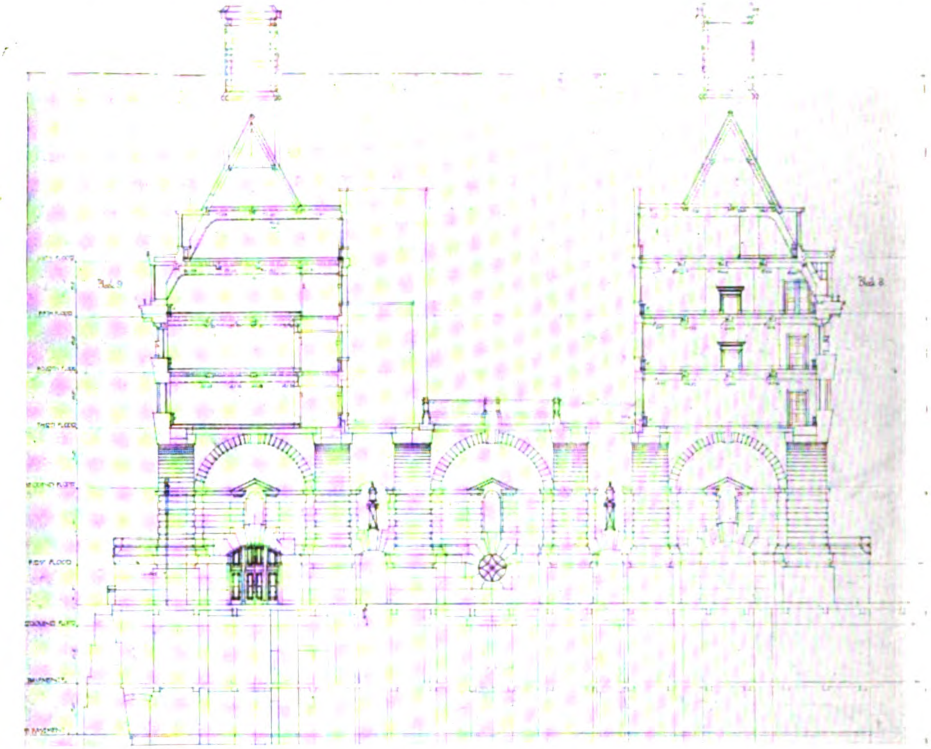


Fig. 2. Cross Section.
THE NEW COUNTY HALL.

of water. The walls vary in height according to the fall of the roads adjoining, but the average depth below the roadway is about 23 ft., and the thickness of the walls generally varies from 10 ft. at the base to 4 ft. at the top.

In addition to the damp course above mentioned a ½-in. layer of asphalt is laid to all piers and walls at a height of 1 ft. 6 in. from the surface of the raft. When a portion of the raft was formed the whole of the work was set out in cement lines on its surface, and the outline of each wall and pier laid with one course of bricks, thus enabling the whole portion to be proceeded with at once.

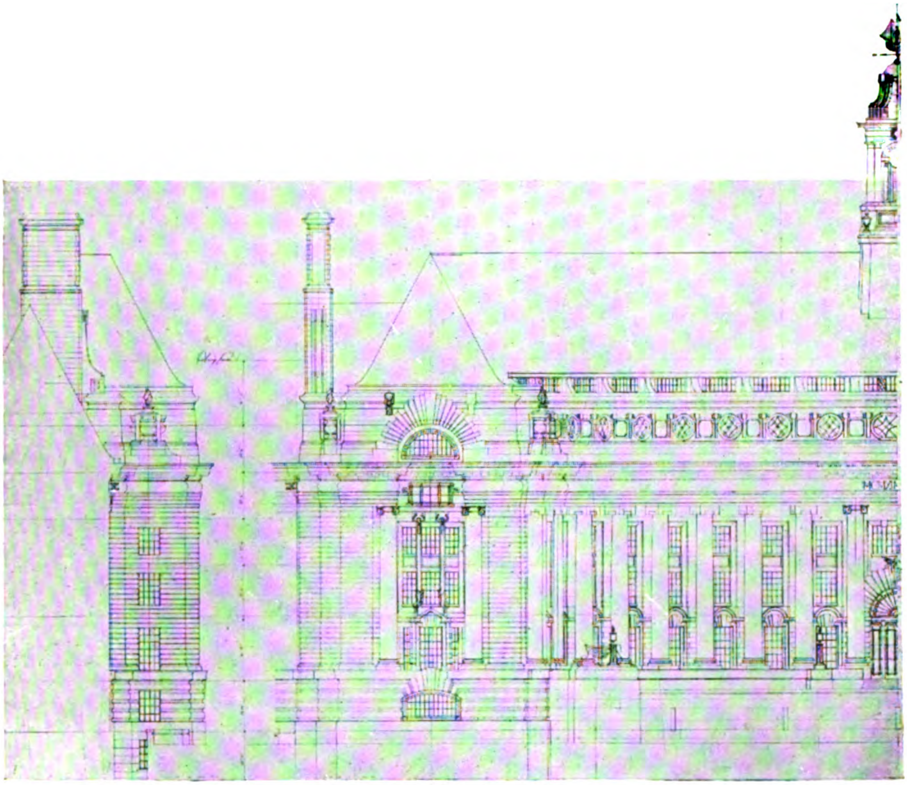


Fig. 3. Elevation to the river.
THE NEW COUNTY HALL.

The building is being constructed of brickwork and steel, and the latter is only used where the former is impossible or undesirable on account of space, and every endeavour appears to have been made to use brickwork for the supporting members in preference to steel stanchions, by the introduction of blue brickwork where the loading is heavy or the size of the bearing surface restricted. It is therefore not a steel-framed structure masked with stone and brick, but rather a brick and stone building with a certain number of stanchions where these were unavoidable. The building is exempt from the provisions of the London Building Act and the supervision of the District

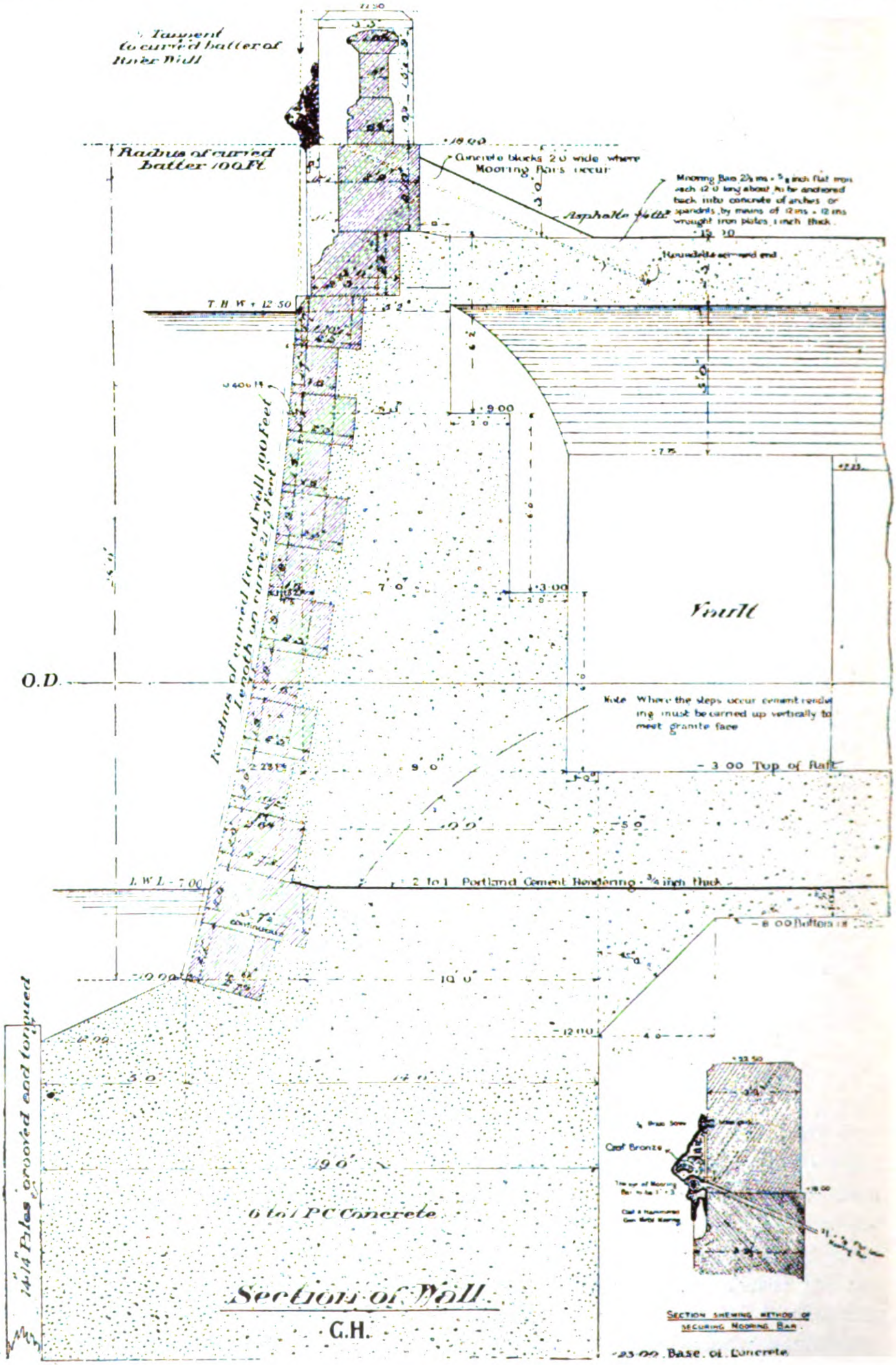
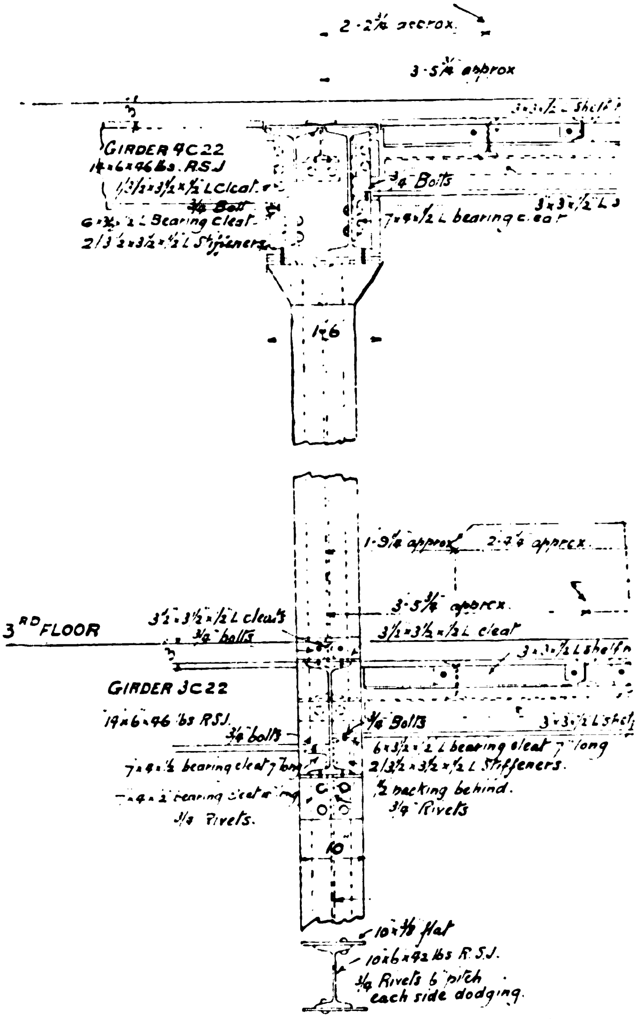

Tangent to curved batter of River Wall
Radius of curved batter 100 Ft
+18.00
Concrete blocks 2 0 wide where Mooring Bars occur
Mooring Bars 2½ ins × ⅝ inch flat iron each 12 0 long about to be anchored back into concrete of arches or spandrils by means of 12 ins × 12 ins wrought iron plates 1 inch thick
Asphalte felt
+15.20
Roundels screwed end
T. H. W. + 12.50
9.00
3.00
Vault
O.D.
Radius of curved face of wall 100 feet Length on curve 21.75 feet
Note. Where the steps occur cement rendering must be carried up vertically to meet granite face
- 3.00 Top of Raft
L. W. L. - 7.00
2 to 1 Portland Cement Rendering · ¾ inch thick
- 8.00 Buttons
10' 0"
-12.00
4.0
14"×14" Piles grooved and tongued
6 to 1 PC Concrete
Section of Wall
G.H.
+23.50
Cast Bronze
Section shewing method of securing Mooring Bar
-23.00 Base of Concrete

Fig. 4. Section of Embankment Wall.
THE NEW COUNTY HALL.

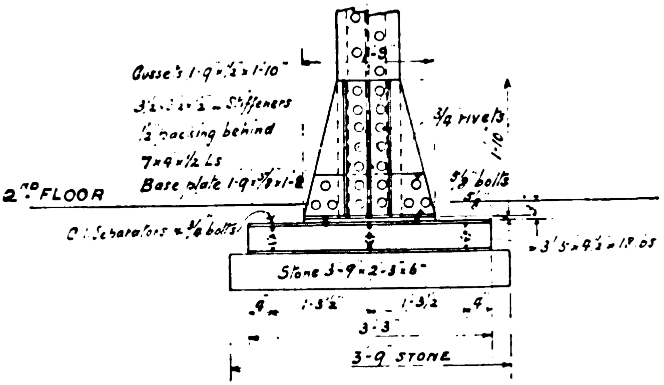
Surveyor, by Act of Parliament, but no advantage was taken of this so far as the requirements were concerned.

No footings were built to the walls, as none are required, all these being carried up from the raft, which ensures a proper distribution of the loads over the soil. The main stanchions have a form of grillage foundation, and this is also placed directly on to the raft and covered with cement concrete to protect the steel from atmospheric influence and moisture. All the loads are therefore taken by the raft and distributed by that over the soil, whether such load is brought down by retaining walls, piers, stanchions, or the ordinary brick wall. This has had the effect of simplifying the underground work to a great extent, as it is quite usual in large buildings to have various types of foundations at different levels, and this renders the construction more difficult for the contractor.

The greatest use of steel stanchions for



SECTION OF STANCHEON S.C.31.



STANCHEON S.C.31

Fig. 5. Steelwork Details.
The New County Hall.

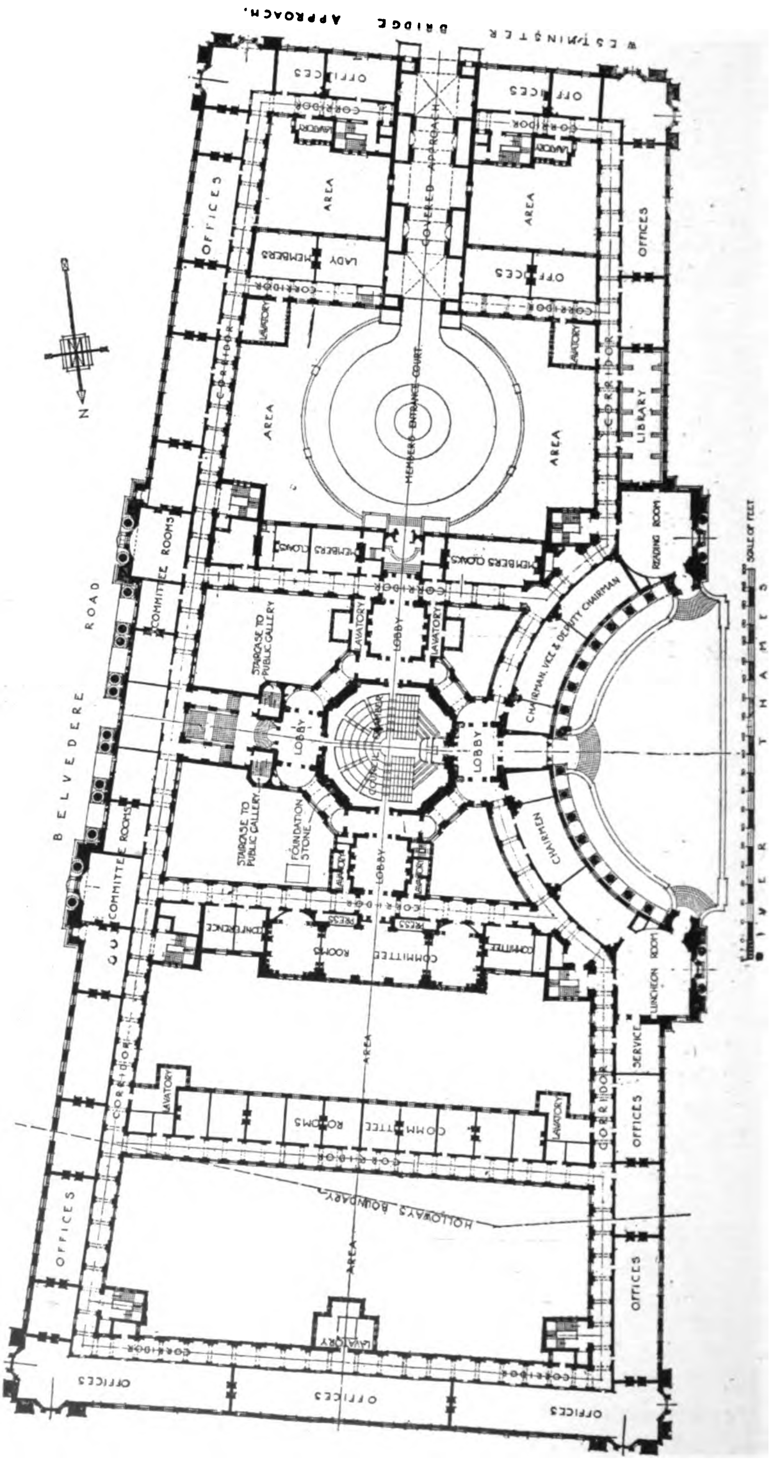


Fig. 6. Plan of Principal Floor.
THE NEW COUNTY HALL.

carrying the superstructure occurs in block 2 of section A, where the boiler-house and ventilating plant occur, as it was necessary to maintain as much open space as possible and large masses of brickwork would have been inconvenient. The latter material is here used as an external casing only. Generally speaking, the external walls vary from 3 ft. to 4 ft. 6 in. in thickness at the base and the internal walls from 1 ft. 6 in. to 2 ft. 7½ in. Some of the piers are an enormous size, particularly in the case of section A, where those in block 3 require 1,400 bricks to each course, and in block 1 900 bricks to each course. There are enormous loads to be carried at various points and brickwork possesses the merit of simplicity, but at the same time the dead load of all this brickwork must add considerably to the pressure on the substructure and the soil. All the brickwork is being built with cement mortar composed of 1 part Portland cement and 3 parts of Aylesford sand, machine mixed, and, generally speaking, slow-setting cement is adopted. The work is built in English bond and each course is laid in mortar and no grouting permitted. White glazed bricks are used for facing the internal areas and all work taking a load of over 8 tons per square foot is built of blue brindled bricks with pressed blue brick facings.

The contractors for the building works here described were as follows:—Messrs. Price and Reeves carried out the Embankment wall, whilst Messrs. F. and H. F. Higgs were responsible for the concrete raft and retaining walls, and Messrs. Chas. Wall, Ltd., for the substructure; the superstructure contract now in progress is being carried out by Messrs. Holland, Hannen and Cubitt, Ltd.

DEFORMATION AND DEFLECTION IN CONCRETE BEAMS.

New Formula whereby Deflection can be Calculated as soon as the loading and size of Beams are known.

The following paper read at the last Convention of the American Society for Testing Materials may be of interest to our readers. We are indebted to the "Engineering Record" for our illustrations.—ED.

THE unit deformations in the steel and the extreme fibre of the concrete in beams are the only determining factors in deflection, except depth, span and method of load distribution, according to a paper read by G. A. Maney at the seventeenth annual convention of the American Society for Testing Materials, held at Atlantic City, June 30th to July 3rd.

A formula has been derived and verified by reliable tests, by which the deflection is equal to the product of a constant into the sum of the deformations at the two extreme fibres. The formula is based upon a certain property of the M/EI curve for any beam—namely, that the deflection of the beam is proportional to the statical moment of the area under the M/EI curve. This curve is obtained by dividing each ordinate of the bending-moment curve by the product of the corresponding values of E and I, which are the modulus of elasticity of the material and the moment of inertia of the sectional area of the beam respectively. The statical moment of the area under the M/EI curve between any two points on the elastic curve, taken about one of these points, is equal to the vertical deflection of this point from a tangent to the elastic curve at the other point. (The beam is assumed to be horizontal.)

PROOF OF THEORY.

The unit stress on the extreme fibre is equal to Mc/I. The unit deformation, e, of that fibre is therefore equal to Mc/EI, and the total deformation in the distance dS along the elastic curve equals $McdS/EI$. Referring to *Fig.* 1, it is seen that this total deformation of the extreme fibre, divided by the distance c from that fibre to the neutral axis, is equal to the change of slope, $d\theta$, in the distance dS. Or

$$d\theta = \frac{Mc\,dS}{EI} \div c = \frac{M\,dS}{EI} \qquad (1)$$

It will be seen that the term $M\,dS/EI$ is equal to the area under the M/EI curve for the distance dS along it; that is, $d\theta$ is equal to a differential element of the area under that curve.

Now, let S equal the distance from any differential element dS to the point at which the deflection is desired. Then, referring to *Fig.* 1, it is clear that the deflection of N' from the tangent MN at M is equal to the sum of the products of each $Sd\theta$ along the elastic curve from M to N, S being measured from N'. Or

$$f=\Sigma S\,d\theta \qquad (2)$$

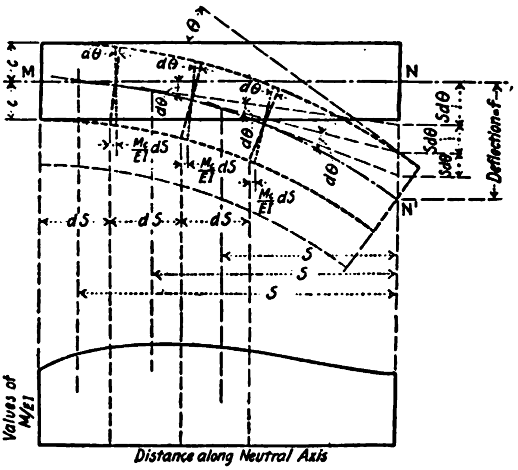


FIG 1. M/EI CURVE FOR BEAM.

But $Sd\theta$ is equal to the statical moment of the differential element of the area under the M/EI curve about N', by the definition of statical moment. Therefore, the deflection of any point from the tangent to the elastic curve at any other point is equal to the statical moment of the area under the M/EI curve about the first point. (In this proof, as in all treatments of the elastic theory, it is assumed that the projection of the neutral axis after bending, upon its original position, is the same as its length before bending.)

This property for homogeneous beams may be expressed:

$$f=kl^2(M/EI) \qquad (3)$$

The value for M/EI in equation (3) will be taken for the point in the beam at which the bending moment is maximum. Then the value of k is such that the statical moment of the M/EI area between any two points, which is equal to the deflection of one point with respect to the tangent to the elastic curve at the other, is expressed in terms of this maximum value of M/EI and the span of the beam, l.

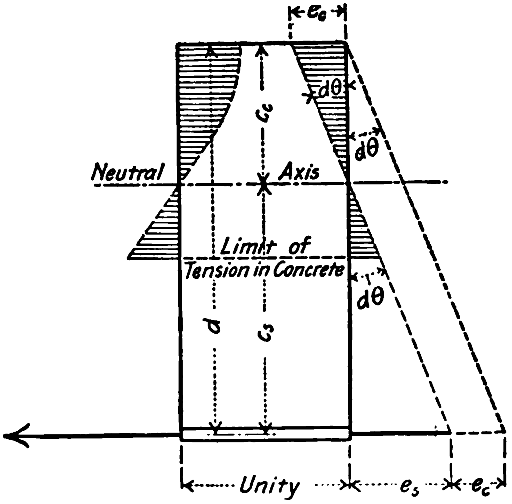


FIG. 2. VARIATION OF STRESS AND DEFORMATION.

It is evident that the value of k for any case is equal to the coefficient of deflection for homogeneous beams in the well-known equation $f=k_1\,W\,l^3/EI$, divided by the coefficient for the maximum bending moment, which in general may be expressed as $M=k_2Wl$, from which $W=M/k_2\,l$. Substituting this in the last equation for deflection,

$$f=k_1\cdot\frac{M}{{}_2kl}\cdot\frac{l^3}{EI}=\frac{k_1}{k_2}\,l^2\left(\frac{M}{EI}\right) \qquad (4)$$

Comparing equations (4) and (3), it is seen that $k = k_1/k_2$. To illustrate, consider the deflection at the centre of a freely supported beam with a single concentrated load at the centre; that is, the deflection of the support with respect to the tangent to the elastic curve at the centre. The coefficient k_1 is 1/48, and k_2 is 1/4. Therefore the coefficient k in equation (3) will become $1/12 = 0.0833$ (see *Fig.* 3b).

The maximum deflection of a simple beam is equal to the deflection of the support from the horizontal tangent to the elastic curve. Usually the maximum deflection occurs at the centre of the beam, as in all cases of symmetrical loading. With irregular loading, it usually occurs near the centre of the beam. Then, by the property of the M/EI curve above referred to, we may express this deflection as the statical moment about the support of the area under the M/EI curve between the point at or near the centre of the span, where the slope is zero, and the support. If this statical moment is expressed in terms of the maximum ordinate of the M/EI curve and the whole span, an expression is obtained of the form of equation (3), in which the coefficient k will equal k_1/k_2.

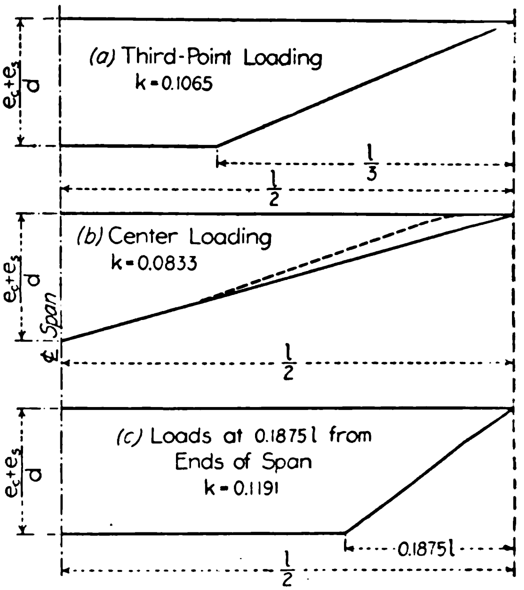


FIG. 3. VARIATION IN VALUES OF $(E_c+E_s)/D$.

It may be of interest here to point out that M/EI equals the rate of change of the slope of the elastic curve, or the change of slope per unit distance. This may be seen by dividing equation (1) by dS, which gives $d\theta/dS = M/EI$.

DEFLECTION OF REINFORCED CONCRETE BEAMS.

The application of this principle to the deflection of reinforced-concrete beams consists in finding a convenient expression for the value of M/EI.

Let e_c and c_c be the unit deformation in the extreme fibre and the distance from the extreme fibre to the neutral axis, respectively, for the concrete, and let e_s and c_s be the same quantities for the steel. In a homogeneous beam, as above indicated, $e/c = M/EI = d\theta$, and is the same for both extreme fibres. In this case, since the values of EI are constant throughout the length of the beam, e/c varies directly as M throughout the span.

In a reinforced-concrete beam (see *Fig.* 2),

$$\frac{M}{EI} = d\theta = \frac{e_c}{c_c} = \frac{e_s}{c_s} = \frac{e_c + e_s}{d} \qquad (5)$$

Substituting this value of M/EI in equation (3), the following expression for the deflection of a reinforced-concrete beam is obtained:

$$f = k\frac{l^2}{d}(e_c + e_s) \qquad (6)$$

This is based on the usual assumption that a plane before bending remains a plane after bending, which seems justifiable from the evidence of reliable tests herein referred to.

From the preceding analysis it is evident that the deformations of the extreme fibres are the only determining factors in the deflection, except the span, depth of beam, and load-distribution. It is also evident that the distribution of the stresses in the steel and concrete over the section has no influence on the deflection, except in so far as the stresses influence the deformations of the extreme fibres.

INFLUENCE OF TENSION.

The influence of tension in the concrete might well be discussed here. From the principles of equilibrium it is known (see *Fig.* 2) that the effect of the tension in the concrete at low stresses is to reduce to some extent the compressive stresses in the concrete and the tensile stresses in the steel. This means that a stiffer beam might be expected in the earlier stages of the loading, as the steeper slope of deflection and deformation curves show.

For the reason, therefore, that tension exists in the concrete and that usually near the end of the beam the rods are bent up, the value of the $(e_c + e_s)/d$ curve, from which the deflection is obtained, will not have the same variation as the values of M.

Near the supports of a simple beam and at all points where the bending moment is small, we would expect considerably smaller values of $(e_c + e_s)/d$ than the value of M at such a point, relative to the value of M at the point of maximum moment would indicate. The values of $(e_c + e_s)/d$ would probably follow the dotted line indicated in *Fig.* 3*b*, because of the tension in the concrete. A glance at *Fig.* 3*b* will show, and computations will prove that a small decrease in values of $(e_c + e_s)/d$ $(= d\theta)$ near the point about which moments are taken (the support, in this case), changes the value of this moment only slightly.

Values of k for maximum deflections under several conditions of loading are here given:

Beam with uniform load:

Ends freely supported, $k = 5/48$ or 0·1041;
Ends fixed, $k = 1/32$ or 0·0313.

Beam loaded at the third points:

Ends freely supported, $k = 23/216$ or 0·1065;
Ends fixed, $k = 5/144$ or 0·0347.

Beam loaded at the middle:

Ends freely supported, $k = 1/12$ or 0·0833;
Ends fixed, $k = 1/24$ or 0·0416.

OUR CONCRETE COTTAGE COMPETITION.

FURTHER DESIGNS SENT IN.

With Design No. 20. **(By Chas. King, 15 Ormonde Road, East Sheen, S.W.)**

Description.

THE accompanying drawings show semi-detached cottages with kitchen, parlour, scullery, and offices on ground floor, and on first floor one large bedroom for two adults and two children and two smaller bedrooms. A good cupboard or larder, with window, is provided, opening out of scullery, also a store cupboard opening out of kitchen parlour, and a fuel store.

The external and party walls to be of concrete, the roof of corrugated iron protected by concrete surface covering. The partitions to be in concrete slabs of the Hercules type.

The elevations are treated simply. The concrete to be exposed as facing material, and only relieved by a few cement quoins and lozenges. The projecting window of staircase is extended to form a shelter over entrance door.

Specification.

Concreter.—Excavate ground as necessary for trenches and floors, etc. The walls to be of cement concrete, 1 part of cement to 6 parts of aggregate carefully deposited and lightly rammed in deal casings with flush joints. Concrete to be laid in courses 18 in. deep, and upper surface left rough to form key for succeeding course. The deal casings to be supported by strong timber framing. The casing to be removed when concrete is thoroughly set. A solution of soft soap to be used to prevent adhesion of concrete to casings.

Floors at ground level to be of similar concrete 6 in. thick, finished with 1-in. cement on surface. Partitions coloured blue to be slab concrete partition of Hercules type.

Corrugated iron roof to be covered with 3-in. cement concrete finished in cement ¾ in. thick. Build bedroom firebacks with firebricks and set fire-bars, set kitchener Hearth to be of cement concrete finished in cement 1 in. thick.

Carpenter and Joiner.—Timbers of approved quality : Purlins, 11 in. by 3 in. ; plates, 4 in. by 3 in. ; ceiling joists, 2½ in. by 2 in. ; joists, 8 in. by 2 in. ; bearers, 9 in. by 3 in. ; 1 in. white deal floor board to bedrooms, and 2½ in. by ¾-in. chamfered skirtings Put picture rails to all rooms except scullery. Front door to be three-panel moulded and square door with upper panel sashed, hung to 4½-in. by 3-in. rebated frame. All other doors to be 1-in. ledged doors hung to 1-in. linings with ½-in. stops planted on. Put all necessary butts, cross garnets, locks, and fastenings complete.

Windows to have 1½-in. casements and 4-in. by 3-in. frames, and mullions with butts, stays, and fastenings complete.

Form lower portion of staircase window with 4-in by 3-in. posts and 4-in. by 2-in. studs and sills.

Put 1-in. matched-board partition to enclose stairs and small bedroom, and 1-in. cupboard fronts with butts and fastenings ; 1-in. shelves and bearers to cupboards. Stairs to have 1¼-in. treads and 1-in. risers, 1¼-in. close strings and 3-in. by 3-in. newel posts complete. Provide and fix dresser, P.C. 25s., kitchen mantel and shelf 10s., and bedroom mantels and shelves 5s. each.

Plasterer.—Lath and two coats plaster to ceilings, and cement dinging to concrete walls and partitions, laid on with a brush and trowelled smooth. Put cement skirtings 3½ in. high to cement floors. Lath and cement two coats lower part of projecting window.

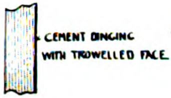
Ironmonger.—4-in. half-round gutters and brackets to detail, and 3-in. slack pipes with hopper head as shown. Provide and set cottage range, P.C. 35s., and to each bedroom fire bars and grate, 5s. each room.

Painter and Glazier.—Glaze all sashes with 16-oz. sheet glass and upper panel of front door with mottled glass. Paint the whole of the work usually painted in four oils.

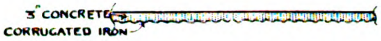
Fittings.

	£	s.	d.
Cottage kitchener	1	15	0
Bedroom stove, bars, and grate	0	5	0
Ditto ditto	0	5	0
Kitchen mantel	0	10	0
Bedroom mantel	0	5	0
Ditto	0	5	0
Dresser	1	5	0
	£4	10	0

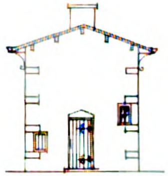
CONCRETE COTTAGES



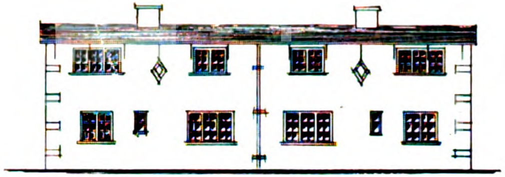
CONCRETE WALL



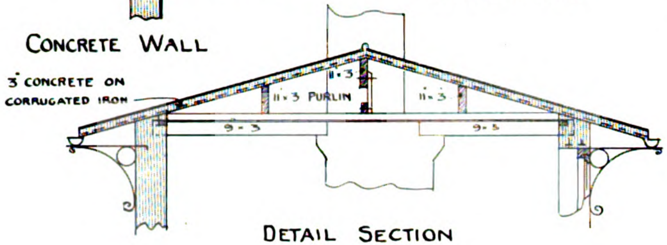
CONCRETE ROOF



END ELEVATION

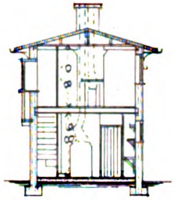


BACK ELEVATION

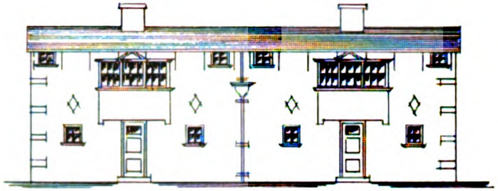


DETAIL SECTION

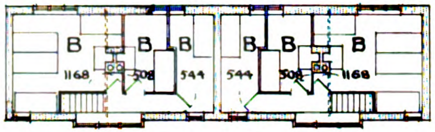
½ INCH SCALE



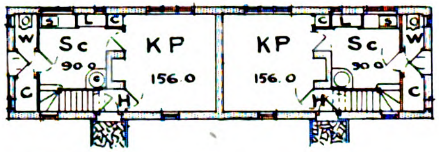
SECTION.



FRONT ELEVATION

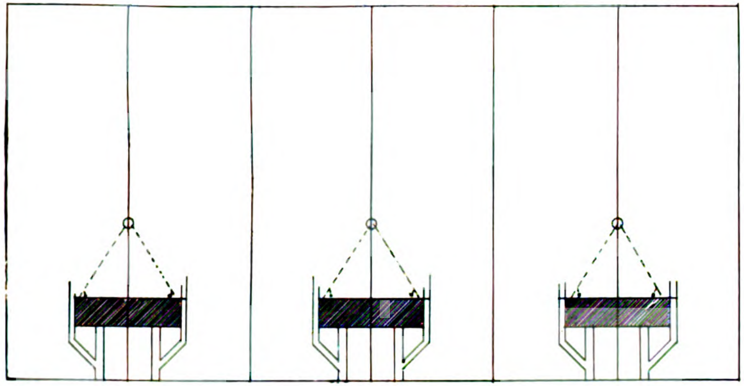


FIRST FLOOR PLAN



GROUND PLAN

⅛" SCALE



CUBICAL CONTENTS

8820 FEET

BLOCK PLAN

$\frac{1}{32}$" SCALE.

TABLE

ROOM	LENGTH	BREADTH	AREA	HEIGHT	CUBE
KP	13.0	12.0	156.0	8.6	1326
SC	10.0	9.0	90.0	8.6	765
B	12.0	11 9	146.0	8.0	1168
B	10.0	6.4	63.6	8.0	508
B	13.0	5.3	68.0	8 0	544

DESIGN NO. 20 ... BY CHAS. KING.

Estimate.

	£	s.	d.
About 55 yards cube concrete in wall, @ 15s.	40	0	0
About 5½ squares of roofing, timbers, etc., @ £4	22	0	0
About 3½ squares of timber flooring, @ £3	10	10	0
Concrete slab partition, say	2	0	0
About 36 yards super concrete flooring, @ 3s.	5	10	0
10 windows, average 25s.	12	10	0
1 front door	1	5	0
8 internal doors	9	0	0
Cupboard fronts	2	0	0
Fittings as list	4	10	0
Plasterer, say	4	0	0
Ironmonger, say	4	0	0
Painting, etc.	7	15	0
	£125	0	0

With Design No. 21. (By Percy May, 235 Devonshire Road, Forest Hill, S.E.)

Description.

The cottage stands upon a black (asphalte) base; the ground floor walls are lime-whited on the concrete left rough from the centering, while the first floor wall timber framed with concrete in-filling, and set back 6 in. from the general face, is covered with silver grey "Fibrocement" sheeting, a similar material being used for the roof. All woodwork, internally and externally, is solignumed. The casement window is used.

As regards plan, the central staircase is the keynote, having on one side the living room, lighted east and west, and on the other a bedroom, while behind is the scullery with bath and copper and separate w.c. The rain-water tanks shown are not included in the estimate.

The floors are covered with a strong linoleum, laid direct on the concrete with mastic. Several cupboards are provided.

The first floor contains two bedrooms with hanging cupboards, and also a large cupboard.

Flues are carried up over staircase to central stack.

Foundations are shown as 9-in. concrete, 12 in. below ground level; this might be diminished according to the nature of the subsoil.

Specification (not in detail).

Clear Ground.—Clear ground and remove 4 in. of surface earth over site, excavate trenches as shown.

Hardcore.—Fill in over site after foundations are in with small sound hardcore, well rammed.

Sand.—Sand to be coarse, sharp, and clean.

Ballast.—Ballast to be clean screened Thames ballast, free from sand, clay, or other impurities.

Cement.—Cement to be Portland cement of British manufacture, and to satisfy all requirements of the British Standard Specification.

Reinforcement.—Steel reinforcement to satisfy requirements of the British Standard Specification, free from defects, grease, scale, or other surface covering, and to be $\frac{3}{16}$ in. diameter and ·094 lb. per ft., bindings to be annealed steel wire, No. 16 B.W.G., placed at 12-in. centres both ways in ground floor walls and floor over.

Centering.—Centering for reinforced work to be rigid and unyielding, all corners filled and all edges splayed, wedges and clamps to be used in preference to nails, limewhite centering before reinforcement is put in. Centering not to be removed from concrete under five weeks.

Concrete.—Concrete for reinforced work to consist of 4 parts ballast to pass ¾-in. ring, 2 parts sand, 1 part Portland cement, mixed three times dry on wooden platform, and three times after clean water has been added through a rose. Concrete must be of such consistency as not to drip water through centering.

Concrete In-filling.—Concrete for in-filling to framing first floor to consist of 6 parts clean coke breeze to pass 1½-in. ring and 1 part Portland cement, mixed twice dry and twice wet as before.

Floors.—Surface of floors to be finished to a level surface with wood float to take linoleum.

Asphalte.—Cover off-set and 6 in. above ground with approved asphalte in one ½-in. layer.

Tar.—Tar over hardcore before ground floor concrete is put in.

Drains.—Drains to be in accordance with the local bye-laws and regulations (not included).

Bed Frames.—Bed and point and grout all door and window frames in cement.

Roof.—Cover roof with "Fibrocement" tiles laid diagonally according to maker's specification on 1½-in. by ¾-in. battens, ridges and hips bedded and pointed in cement, finish around chimney with zinc flashing and cement drip.

Timber.—Timber to be well-seasoned yellow fir, free from knots, etc; for joiners' work to be yellow St. Petersburg, etc.

Framing, etc.—Frame up first floor walls (externally) with 4-in. by 3-in. timbers properly braced at angles and housed to head and cill, the latter to be spiked to concrete, fill in with concrete and cover with "Fibrocement" sheeting on 1½-in. by ¾-in. battens, cover soffits with ¾-in. matched boarding, rafters 5 in. by 2 in., ceiling joists 5 in. by 2 in.; internal framing, 3 in. by 2 in. properly braced.

Windows.—Frames, 4 in. by 3 in., rebated; cills, 7 in. by 3½ in., hardwood weathered; sashes, 1½ in., glazed in small panes, architraves, rails, etc.

Doors.—Front entrance, 1½ in., framed and glazed; lower part, ¾-in. V-jointed boarding, other doors, ledged and braced ¾-in. boarding, architraves, etc.

Stairs.—1-in. treads and risers, 1½-in. strings, carriages, etc., skirtings, etc.

Cupboards.—Cupboards, dresser, etc., all to detail.

Gutters, etc.—Gutters, 4 in. by 3 in., C.I., square screwed to facia outlets, etc. R.W.P.'s, 4 in. diameter, C.I., socketed, caulked joints, shoes, etc.

Water Supply and Fittings.—(Not included).

Plaster.—Walls and ceilings setting only ground floor. Lath, plaster, float, and set walls, partitions and ceiling first floor.

Glazier.—Glaze windows and door with 21-oz. sheet.

Paint.—Paint all woodwork internally and externally, 1 coat "Solignium" before fixing, and 1 coat after. Paint 3 coats oil all ironwork. Distemper walls and ceiling.

Fittings.—Locks, hinges, catches, and window stays, etc. Range, bath, copper, etc.

Rough Estimate of Cost.

Excavations.	About 10 yards cub. @ 1s. 3d.	0	12	6
Concrete.	About 6 yards cub. @ 12s.	3	12	0
	Extra on internal work, partitions, etc.	6	0	0
Concrete Reinforced.	About 85 yards sq. @ 9s.	38	5	0
First Floor.	About 520 ft. sup @ £3 10s. per sq.	18	4	0
Roof Complete.	About 500 ft. sup. @ £3 10s. per sq.	17	10	0
Windows & Doors.	About 350 ft. sup. @ 1s. 9d. (including stairs, etc.)	25	12	0
Plaster.	Ground Floor setting, first floor complete, distemper and limewhite	10	0	0
Fittings.		4	9	1
		£124	4	7
	Cubic contents of building :—24 15 9·5 × 23 14 8·5 = 6,156 cub. ft.	£	s.	d.
	6,156 cub. ft. @ 1d.	25	13	0
	6,156 cub. ft. @ 4¾d.	122	6	9

The above price might be adequate if the cottages were built in pairs—*i.e.*, the south wall being a party wall

With Design No. 44. (G. Ll. Morris, Licentiate R.I.B.A., 40 Finsbury Square, E.C.)

The £125 Cottage.

Character of design.—The author has attempted to realise a pleasant, artistic, and inexpensive design along lines suggested by the nature of the chief material and the method of construction. Concrete has been frankly accepted as the chief factor in its treatment, and this has called for a design distinct from those based on the old traditions of cottage building. Care has been taken to obtain a good arrangement of voids and solids. It is also proposed that the elevations should be generally whitewashed, and the portion under the ground-floor windows tarred to the height shown, and also the curved portions between windows. It should be noticed that the line showing the base on the elevations is not constructional, but merely indicates the top of the tar base all round the cottage. Parts of the cornice also would be tarred. The window and door frames externally to be painted black and the sliding casements and dividing bars white. The general effect aimed at being white and black, the white predominating. The cube of the cottage has been taken from the top of the foundations to 1 ft. above the flat roof.

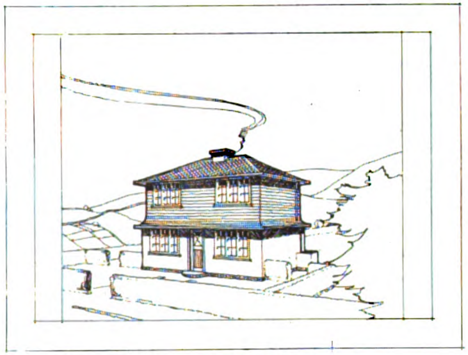
Brief Description of Concrete and Specification of its Method of Execution.

Excavate trenches for foundations, fill in with concrete, level and ram same; strip off the vegetable soil over the site and fill in with hard clinker ashes or broken stone. Cover same with a 4-in. concrete slab, the concrete composed of five parts of clean boiler ashes to one part of Portland cement. The concrete for the external and internal walls to be composed of carefully selected materials combined with Portland cement to pass in every respect the British Standard specification. The gravel must be passed through a screen having a circular mesh of ¾ in. diameter, and the aggregate graded down from ¾ in. to the size of a pea, and add to the gravel a proportion of sand equal to the amount of water sufficient to fill the interstices in a bucket of clean welted gravel filled level to the top. The sand and gravel must be well washed and free from foreign matter and then well mixed in the proportion of one of cement to six of gravel and sand. Each particle of aggregate must be thinly coated with cement grouting and the interstices filled with the smaller proportions of aggregate. The concrete must be thoroughly wetted in the mixing and kept wet for a few days and put down in a thoroughly wet mass. In casting the slabs for the reinforced flat roofs, put down 1 in. of good ash concrete and cover over immediately with the gravel concrete.

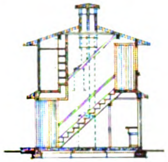
Method of execution for the external walls.—The external walls are to be cast in slabs, three for the front, two for each side, and six at the back; the six at the back divided as follows: two for the

A CONCRETE COTTAGE TO COST £125

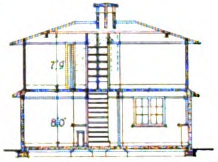
SCALE 8 FEET TO 1 INCH



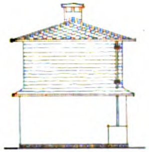
SKETCH FROM S.W.



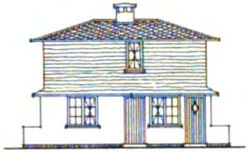
CROSS SECTION



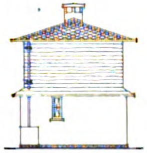
LONG SECTION



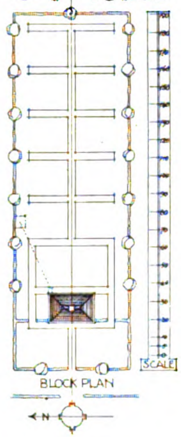
SOUTH ELEVATION



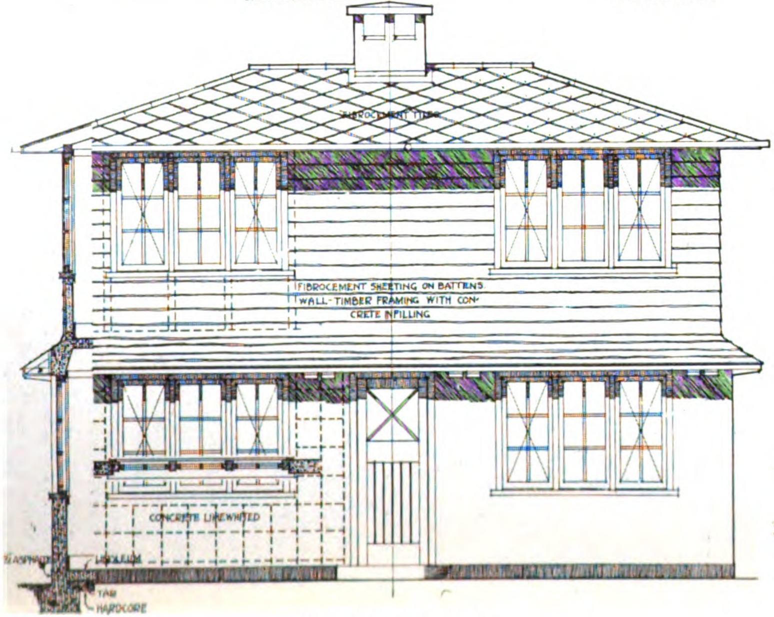
EAST ELEVATION



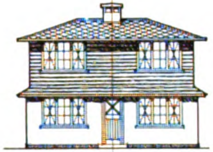
NORTH ELEVATION



BLOCK PLAN


FIBROCEMENT TILES
FIBROCEMENT SHEETING ON BATTENS
WALL-TIMBER FRAMING WITH CONCRETE INFILLING
CONCRETE LIMEWHITED
ASPHALT
LINOLEUM
TAR
HARDCORE

HALF INCH DETAIL OF FRONT

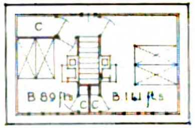


FRONT ELEVATION

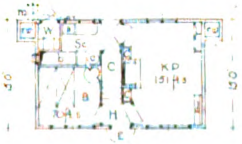
CUBIC CONTENTS

24 / 15 / 9·5 + 23 / 14 / 8·5 = 6156 CUBIC FEET

ROOM	LENGTH	WIDTH	SUPER AREA	HEIGHT	CUBIC CONTS.
H	4'0"	3'0"	12·00	7'9"	93·00
KP	14'0"	11'0"	151·00	7'9"	1180·25
Sc.	8'6"	5'9"	57·875	7'9"	448·531
B. 1	8'9"	8'0"	70·00	7'9"	542·500
B 2	10'6"	8'6"	89·25	7'9"	691·687
B. 3	13'6"	10'6"	141·75	7'9"	1098·562

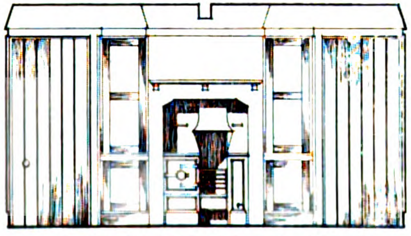


FIRST FLOOR PLAN



GROUND FLOOR PLAN

24'0"



HALF INCH DETAIL OF KP

DESIGN NO. 21 ... BY PERCY MAY

projecting wings, two for the recessed portion (these being horizontal divisions), and two for the short returns. The moulds are to be a raised level staging formed of the reversed sides of the floor boards. The window and door frames laid in position and the concrete poured into the mould and screeded off to the right thickness, 4 in. in the panels between head and ground-floor windows and first-floor sills and 5 in. in the piers between windows and up to ground-floor window cills. The reinforcements consist of ¾-in. steel rods placed 8 in. apart both vertical and horizontal, leaving the rods projecting at the ends ; these are bonded together at the corners and vertical joints, and made good with concrete afterwards. Cornices for the plates to receive the joists to be cast on the walls. The breasts of fireplaces are to be of brick and linked to the reinforced concrete. For this purpose steel rods are to be left projecting from the concrete. The breasts of fireplaces in No. 3 bedroom are to be built on a slab of concrete laid across the angle from the external wall to the internal cross walls. The internal walls are to be 2½ in. thick, cast on the floor. The reinforcements of the flat slab roof are to be 3/16-in. barbed wire of cross mesh 6-in. centres, strengthened with concrete beams on the outside of the roof. The slab to be trowelled after it has properly set. The internal faces of external walls, the faces of partitions and ceilings upstairs to be merely skimmed with plaster at the finish. The external face of concrete walls to be finished with a thin coating of hand-floated cement and twice limewhite. The limewhite to be mixed with alum so that it will not wash off. The mortar for brickwork to be one part stonelime and three parts clean sharp sand. That used for plastering ceilings of ground floor to be mixed with cow hair. Build up the footings of chimneys with two courses of brickwork. Form arches over fireplace openings on wrot-iron bars. Form flues 9 in. by 9 in., parge and core same.

Set range and mantel registers and bed all frames and plates. Finish the whole of the ground floors and the space between projecting wings at back in trowelled cement, and around kitchen range and all hearths. The first-floor joists to be 4 in. by 2 in., plates 4 in. by 2 in., and to be laid with 1-in. yellow deal battens, grooved and tongued, and put round all rooms 3 in. by 1 in. splayed skirtings. All external door frames to be 4 in. by 3 in., solid and rebated ; internal door frames 4 in. by 2 in. in 3-in. partitions and 3 in. by 2 in. in 2-in. partitions, solid and rebated as before. All windows on the front and back elevations to be of the Yorkshire slide type, and to have 6 in. by 3 in. frames rebated for 1½-in. rebated and moulded sliding sashes. The frame at the bottom to project to form sill to be weathered and throated and grooved for cement facing, and to be 7 in. by 3 in. The windows in end elevation to have 4-in. by 3-in. frames, 5-in. by 3-in. sunk, weathered and throated sills, and 1½-in. casements, divided with bars as before, and to be hung with a pair of 2½-in. cast butts and fitted with cockspur fastener and casement stay with two pins. All internal doors to be ledged and batten doors, hung with cross-garnets and fitted with thumb latches complete. The external doors to be 1¾ in., framed, ledged and battened and hung and fitted as before, with thumb latches and locks complete Construct the staircase with 1-in. treads, ¾-in. risers, and 1½-in. strings. Glaze the windows with 15-oz. sheet, well puttied and back puttied. Fix a 3-in. diameter downpipe, with ears cast on shoes at feet. Provide a Larbert portable range. Provide three small mantel registers for bedrooms. Properly prepare, stop, prime and paint all external wood and iron work, painted three coats in good oil colour. Size and stain all internal woodwork. Clean all floors and windows and leave perfect at completion.

The estimate for the pair, including fittings :—

	£	s.	d.
Concrete floors and flat and down pipes	25	0	0
„ walls and partitions	70	0	0
Brick chimneys	20	0	0
Wood floors (first floor)	10	0	0
Skirtings	5	0	0
Windows	30	0	0
Glazing	5	0	0
Doors	25	0	0
Painting	10	0	0
Plaster, externally and internally	20	0	0
Staircases	12	0	0
Cupboards	5	0	0
Shelves, racks, etc.	2	0	0
Dresser and fittings	2	0	0
Ranges and mantel registers	9	0	0
	£250	0	0

NOTE.—The cube, 11,053 ft. 8 in., at slightly under 5½d. per cub. ft., works out at £250. No water supply, sanitary work equipment, fencing, paths, or land drainage is included in this estimate.

With Design No. 124. (By Austin Vernon, 5 Duncan Terrace, Islington, N.)

Description.

THE erection of a cottage in solid materials like concrete for £125 is a difficult problem, and only by pinching every detail very tight can one expect to get anywhere near such a figure.

In the design the following points have been in the author's mind as ways of keeping the price as low as possible.

1. A low one-storey building reduces the scaffolding and plant required to a minimum, also labour in connection therewith. It also saves a great deal of labour raising materials to a height.

2. Manufacture of concrete blocks on the site with materials obtainable locally as far as possible as aggregate. By this means it is possible to handle the concrete in a more convenient form. Whatever locality one may select some good aggregate is usually to hand.

Concrete blocks can be manufactured by unskilled labour on a rough boarded platform divided by boards of the size necessary for the required thickness—say, 2 ft. by 1 ft. by 5 in. Smaller blocks would also be required about the size of bricks for constructing flues, &c. The fronts of the fireplaces could also be cast in a similar manner about 3 in. thick and grouted solid in position Shelves, steps, sinks, and lintels could all be cast to sizes given.

The building could be roofed with pantiles, or with a cement tile, which could be tarred, and would give an artistic effect in contrast to the rough-cast.

With regard to plan, space is arranged beside copper for a folding bath. A Larbert range is proposed in the kitchen-parlour. Cement floors to kitchen-parlour, entrance, and scullery. Bedroom floors could be boarded, but these might well be finished cement. The space not lettered on plan is for wood and coals.

Specification.

Excavator to remove virgin soil and spoil from trenches to be spread over site of building to raise level.

Concrete in foundations and over site 5 parts obtainable—aggregate say, broken brick—to 1 part clean sand and 1 part standard Portland cement. All mixed together on a boarded platform turned over twice dry, wetted with a rose, turned twice wet, gently tipped into trenches and over site, and lightly punned. Damp course of 2 courses of slates in cement.

Concrete blocks for walls cast on a boarded platform, each a convenient size—say, 2 ft. by 1 ft. by 5 in. thick—composed of 4 parts of small broken brick to pass a 1¼-in. ring, 1 part of clean sand, 1 part cement.

Concrete bricks for building flues, coppers, &c. (about the size of ordinary bricks), cast as before: broken brick to pass a 1-in. ring.

Fronts of fireplaces to be cast 3 in. thick on the platform as before, and finally finish with a smooth face in cement and sand.

Concrete lintels to be cast as before to required sizes, reinforced with gas barrel.

Cast concrete shelf in larder 2 in. thick finished with a smooth face as before.

Hoop-iron ties to be used as necessary for tieing in the angles and securing wall plates.

Carpenter and Joiner.—Rafters and collars 4 in. by 2 in. Ridge 6 in. by 2 in. Plates 4 in. by 2 in. Roofing battens 2 in. by 1 in. Bedroom floors ⅞-in. flooring nailed to dovetailed fillets bedded in concrete.

Door and window frames 3 in. by 2 in. rounded and rebated, and small moulded fillet planted round inside and out.

Doors ledged and braced and covered with ¾-in. matchboard. Front door to be 1¾ in., square panelled, upper part framed for glazing in small squares with bars. Casements 1½ in., rebated and rounded, divided in squares by bars. Tiers of shelves in cupboards, in larder and scullery.

Tiler.—Cover the roof with approved pantiles, bedded and torched inside. Or with “Poilite’ corrugated cement Roman roofing tiles.

Plasterer.—Bedrooms, kitchen-parlour and entrance, render walls and partitions in cement to obtain a fairly smooth surface and set in “Serapite.” Ceilings, lath, prick up in coarse stuff, lime gauged “Serapite” and float and set in putty gauged “Serapite.”

Rough-cast, rough render in cement and dash on small rough-cast of fine gravel and cement, and finish with a brush.

Eaves gutters, 4-in. cast-iron half-round down pipes 3-in. cast-iron shoes and swannecks.

Glazing.—16-oz. sheet glass.

Painter.—4 oils on all wood and iron-work usually painted, fast distemper walls and ceilings.

Tar plinth and cement roofing tiles.

Drainage (not included in estimate).—Iron vent pipe fixed on side of house at head of drain, stoneware drains jointed in cement, concrete manhole and cesspool rendered inside in cement and sand. Stoneware pedestal closet and gulley.

No fences, paving, water supply and no carting away allowed for.

Estimate.

Cube. 37 ft. 6 in. × 17 ft. × 14 ft., *less* 17 ft. × 5 ft. × 2 ft. 6 in. = 8,725 cub. ft.
8,725 ft. @ 3d. per ft. = £127 3s.
8,725 ft. cub. @ £125 equals 3.43d. per ft.
Roughly £22 per room.

Cost of Separate Items.

	£	s.	d.
Concrete, about 65 yds.	50	0	0
Roof, at £5 per square	22	10	0
Joinery	17	0	0
Plastering	30	0	0
Fittings	5	10	0
	£125	0	0

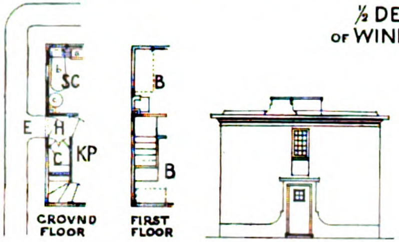
£125-CONCRETE-COTTAGE COMPETITION

SCALE 10 5 0 10 20 30 40 50 60 70 80 FEET

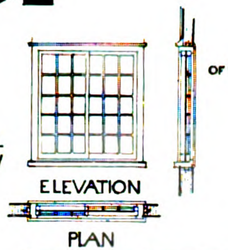
	SIZES	AREAS	HEIGHT	CVBIC CONT^TS
LIVING RM	13·1 × 11·9	153·9	7·6	1153·1½
SCVLLERY	8·6 × 8·0	68·0	"	510·0
BED-RM I	14·6 × 9·0	130·6	"	978·9
BED-RM II	8·6 × 8·0	68·0	"	510·0
BED-RM III	8·6 × 8·0	68·0	"	510·0
LARDER	3·6 × 2·6	8·9	"	65·7½
CLOSET	5·6 × 2·10	15·7	5·6	85·8½
W·C	3·6 × 2·6	8·9	7·6	65·7½
COAL	3·6 × 2·9	9·7½	"	72·2¼

THE CVBE 11053·8

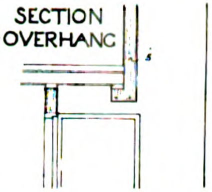
TABLE



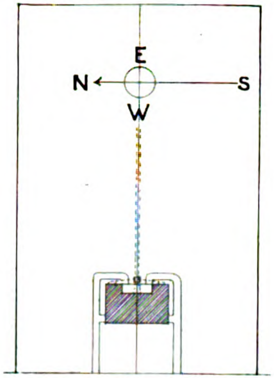
ALTERNATIVE-SIDES



½ DETAIL OF WINDOW

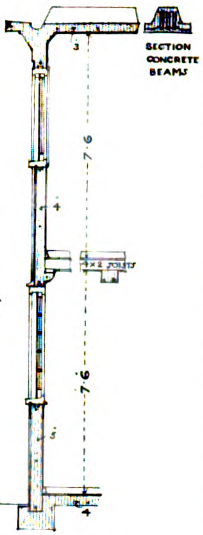


SECTION OF OVERHANG



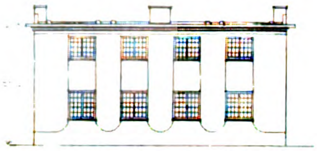
SITE PLAN

SCALE 10 0 10 50 100 120 FEET

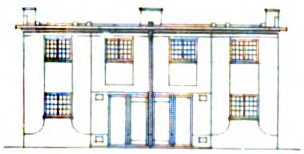


SECTION THRO' FRONT WALL

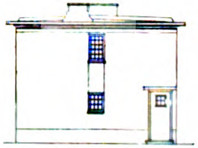
½" SCALE



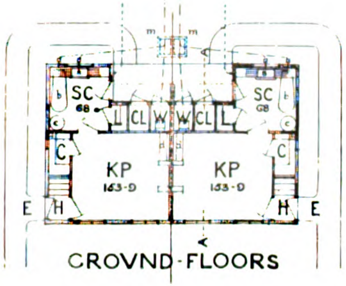
FRONT



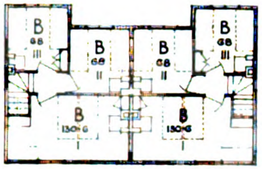
BACK



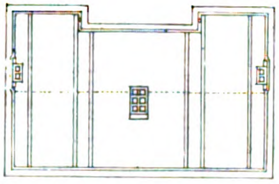
SIDES



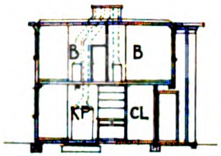
CROVND-FLOORS



FIRST-FLOORS



ROOF



SECTION-A-A

DESIGN No. 44 ... BY G. LL. MORRIS, LICENTIATE R.I.B.A.

OUR CONCRETE COTTAGE COMPETITION.

With Design No. 238. (By R. I. McBeath, Birnam House, Sale.)

Description.

THE design is manifestly so simple and straightforward that little or no description of the planning appears necessary. The following merits may, however, be pointed out :—

1. The Kitchen-Parlour is free from any passage way between one room and another in the vicinity of the fire or window.
2. The Scullery provides ample and good spaces for sink and bath with short direct wastes from each discharging over one gully.
3. The Staircase is of good width and well lighted.
4. The Bedrooms provide good positions for the requisite twin beds and with easy access thereto.
5. The w.c. and Coal Store are each approachable under cover, yet to all intent outside the dwelling.

It is proposed to erect the cottages with 10 in. external walls, consisting of two 4½ in. solid concrete blocks with an inch cavity between and bonded with galvanised iron ties. The ground floor rooms would have 4½ in. solid block walls, and the first floor rooms 2 13/16 in. cement slab partitions. The ground floor is proposed to be of concrete 5 in. thick, and the first floor of Johnson's lattice reinforced concrete 4½ in. thick. Each floor would be screeded up to the foregoing thicknesses and trowelled to a smooth face to receive linoleum if desired, and all rooms would have fibro-cement skirtings. The roof would be covered with fibro-cement slating laid diagonally to a 2¾ in. gauge with Willesden paper underlinings, and provided with fibro-cement ridging.

Specification.

Concretor.—Excavate trenches for walls and spread soil at back of site.

Fill in concrete foundations 18 in. wide, 5 in. thick, to external and party walls composed of one part Portland cement, 2½ parts clean sand and 5 parts broken stone or ballast well rammed until solid and level.

Build all external walls 10 in. thick of 18 in. by 9 in. by 4½ in. concrete blocks, built 1 in. apart to form a continuous cavity, and bond with three galvanised wrot-iron ties every super yard. All blocks to be bedded and jointed with Portland cement, and all external angles to have rock-faced quoins.

Build internal ground floor walls with 18 in. by 9 in. by 4 in. solid concrete blocks, and the first floor walls with 28½ in. by 9 in. by 2 13/16 in. solid concrete partition slabs with interlocking end joints set in cement.

Build party wall and chimney breasts with 18 in. by 9 in. by 4½ in. concrete blocks set in cement.

All blocks and slabs to be made in a " Winget " machine, and to be composed of one part British Standard Portland cement, 2 parts clean washed sand, and 4 parts hard freshly crushed stone well graded up to ¾ in. All blocks to stand one month to dry before being used. All walls to have bitumen damp-proof course.

The internal wall faces of Scullery, Larder, w.c. and Coals to be neatly jointed up and receive two good coats of limewash.

External door and window openings to have 10 in. by 9 in. concrete heads reinforced with steel rods. All internal door and fireplace openings to have 9 in. by 4 in. or 9 in. by 3 in. concrete lintels as required. Doorways to have 10 in. by 6 in. concrete thresholds.

Chimney to have 9 in. by 7 in. concrete capping and eight terra cotta conical pots flaunched with cement.

Flues to be 9 in. by 9 in. well parged and cored.

Lay the ground floor throughout with Portland Cement concrete 4 in. thick, composed of one part British Standard Portland cement, 3 parts clean sand, and 5 parts clean aggregate broken to pass through a 2½ in. mesh and screed the same 1 in. thick with equal parts cement and fine granite spar trowelled smooth and level.

Lay the first floor throughout with Johnson's lattice system reinforced concrete flooring 4 in. thick, composed of one part British Standard Portland cement, 2 parts clean washed sand, and 4 parts hard freshly crushed stone well graded up to ¾ in. The whole to be laid upon suitable sheeting and propping, and to extend over all ground floor partition walls and 4½ in. over all external and party walls and to be screeded up ½ in. thick with equal parts cement and fine granite spar trowelled true and level to receive linoleum.

Form concrete hearths to fireplaces in like manner to floors.

Reinforced concrete beams to be formed in ground floor ceilings to carry partitions above.

The stairs to be formed of molded reinforced concrete mixed 1, 2, 4, as specified for first floor, reinforced with ⅞ in. diameter steel bars, slightly rounded on front arris and built in as walls proceed.

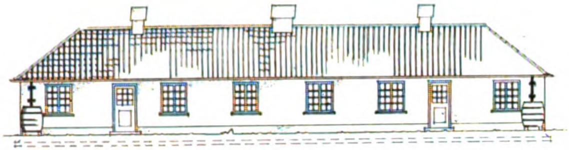
Provide and set in each Kitchen-Parlour one 3 ft. range and iron mantel, p.c. value 60s.

Provide and set in each cottage two 30 in. iron mantel registers, p.c. value 10s. 6d.

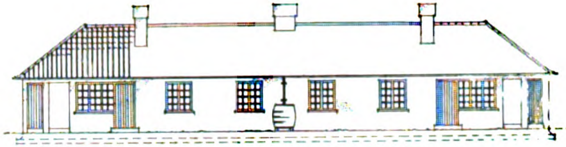
Slater.—Cover the roofs and dormer cheeks with 15¾ in. by 15¾ in. red fibro-cement slates, laid diagonally with lapping edges to 2¾ in. gauge upon 1½ in. by ¾ in. red deal sawn battens, each slate secured with two galvanised steel nails and one copper clamp.

DESIGN FOR A PAIR OF SEMI-DETACHED CONCRETE COTTAGES.

SCALE 8 FEET TO 1 INCH



FRONT ELEVATION

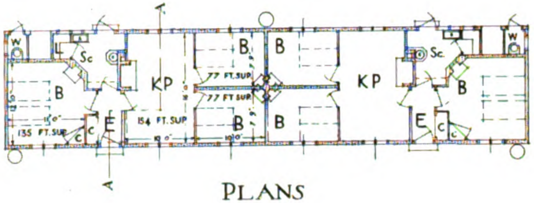


BACK ELEVATION

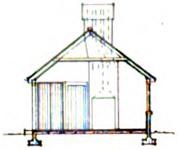
TABLE.

ROOM	DIMENS	AREA	AVERAGE HT	CUBE
EH	3'3"×7'9	FT. SUP 25	8 FT 6 INS	FT. CUBE 230
KP	16'0"×10'0"	154.	Do.	1309
Sc.	8'0"×8'0	36	Do.	306
B 1	12'0"×11'0"	135	Do.	1148
B 2	10'0"×7'9"	77.	Do.	654
B 3	10'0"×7'9	77	Do.	654
L	2'6"×3'6"	8	Do.	74.

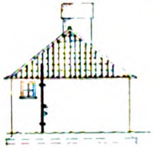
TOTAL CUBE.
8725. FEET.
EACH COTTAGE.



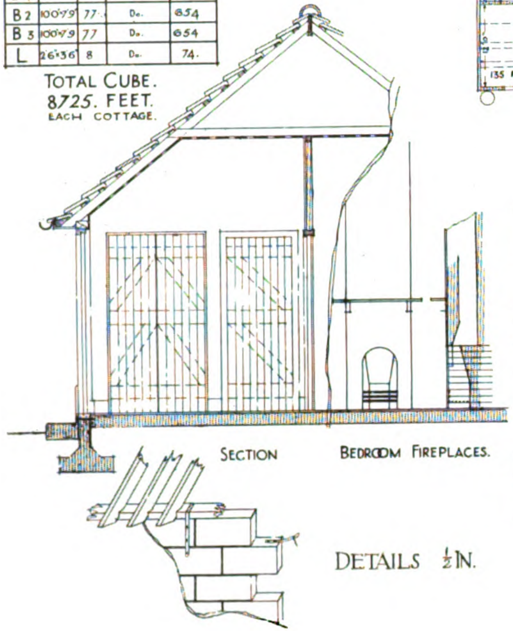
PLANS



SECTION·AA



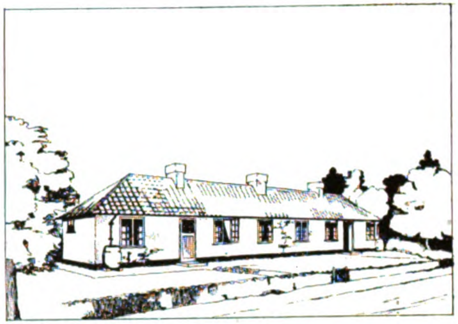
END

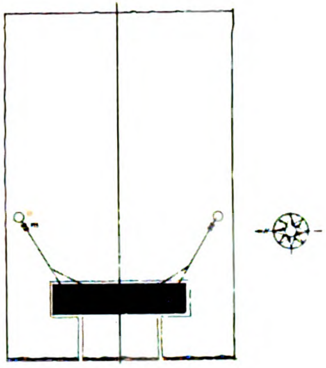


SECTION

BEDROOM FIREPLACES.

DETAILS ½ IN.





BLOCK PLAN

DESIGN NO. 124 ... BY AUSTIN VERNON.

Fix red fibro-cement angular ridging to roof, well secured with copper ridge clips.

Plasterer.—Render and set all internal wall faces except Larder, Scullery, w.c. and Coals.

Render and set ceilings of all ground floor rooms except Larder, w.c. and Coals.

Lath with Baltic fir, plaster and set all first floor ceilings, bulkheads and dormer cheeks.

Flush point all door and window frames with cement.

Carpenter and Joiner.—Roof timbers to be of spruce—wall plates 4 in. by 3 in., purlins 11 in. by 3 in., rafters 3 in. by 2¼ in., ceiling joists 3 in. by 2 in., ridge 7 in. by 1¼ in.

Cover the rafters with Willesden two-ply underlining paper.

Fix eaves pole to all eaves and cover overhanging eaves and gables with ¼ in. fibro-cement sheeting.

Fix 4½ in. by ¾ in. fibro-cement chamfered skirting round all walls and stairs except Larder, w.c. and Coals.

All door and window frames to be 4½ in. by 3 in. solid rebated and molded red deal, the window frames having 7 in. by 3 in. sills.

Casements to be 2 in. molded and rebated red deal, hung with 2½ in. butts and secured with black wrot-iron stays and fasteners.

Window bottoms to be 1¼ in. rebated tongued red pine.

All door casings to be 1 in. pine with ½ in. stops, and to have 3 in. by 1 in. single molds planted round.

All external door and window openings in plastered walls to have 1 in. angle beads for plaster. External angles to have similar beads.

Front entrance doors to be 1¾ in. red deal, square framed and panelled with frieze panel for glazing.

Internal doors in Kitchen-Parlours to be 1½ in. pine, four panel, double molded.

All remaining doors to be 1 in. red deal, edged, battened and faced.

Front doors to be hung with 4 in. butts and 6 in. mortise lock and brass postal handle and knocker.

All remaining doors hung with 12 in. garnets and Norfolk thumb latches, back door having 6 in. rim lock and brass furniture instead.

Frame dormers with 3 in. by 2 in. spruce, cover cheeks with ¼ in. fibro-cement sheeting to receive slates.

Provide and fit up in recess of each Kitchen-Parlour a cupboard with three drawers in lower portion and three shelves in upper portion.

Larders to have 11 in. by 1 in. Baltic white deal shelving.

Plumber and Glazier.—Fix 4½ in. half-round iron gutters on wrot-iron straps to rafters, with all necessary stopped ends, spitters, etc.

Fix 2½ in. diameter cast-iron fall pipes on projecting holderbats with all necessary open heads, swannecks, shoes, etc.

Flash and step flash chimney and dormer cheeks with best 4 lb. milled lead.

Glaze windows with 21 oz. clear sheet glass.

Glaze w.c. window and front door frieze panel with ¼ in. rough plate.

Painter.—Clean, prepare and paint all ironwork two coats of oil paint.

Clean, prepare and stain all woodwork with green Solignum, and varnish same.

Prepare and tint all plastered walls and ceilings with "Walpamur."

Cost, &c.

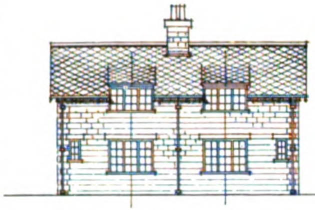
The cubic contents of the pair of cottages measured in accordance with your conditions—viz., to half way between ceiling and apex of roof—are as follow:

32 ft. 1 in. × 23 ft. × 19 ft. 10 in. = 15,091 cu. ft.
Upon this basis the estimated cost of the cottages is
15.091 cu. ft. @ 4d. = £251 10s. 4d.

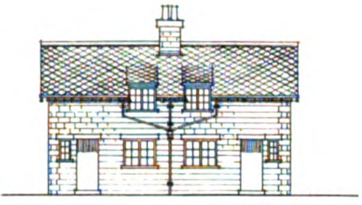
The following details set forth the manner in which the above-named estimated cost has been arrived at, the whole of the work having been priced out:

	£	s.	d.
Excavating wall trenches	0	10	0
Concrete floors (ground and bedroom)	30	14	3
Concrete wallings, partitions, foundations, thresholds, heads, lintels, stairs, bond irons, damp-proof course	87	7	6
Fibro-cement slating and ridge	19	8	3
Carpenter and joiner work	54	5	4
Plasterer's work	20	4	1
Gutters, fallpipes, and glazing	10	1	11
Painter's work	17	0	0
Ranges, grates, mantels, chimney pots, and setting	11	18	0
	£251	9	4

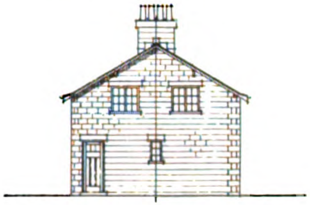
£125 CONCRETE COTTAGES



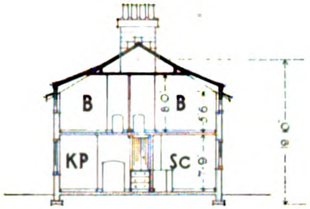
FRONT ELEVATION



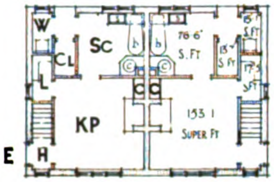
BACK ELEVATION



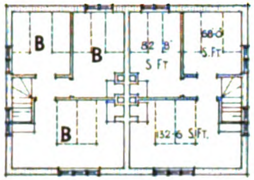
SIDE ELEVATION



SECTION

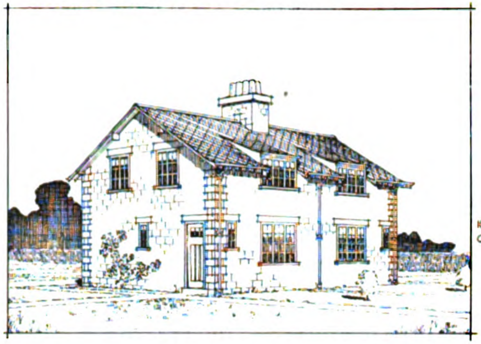


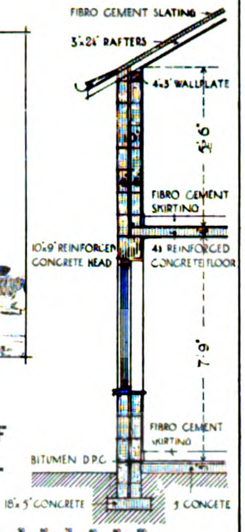
GROUND PLAN



BEDROOM PLAN

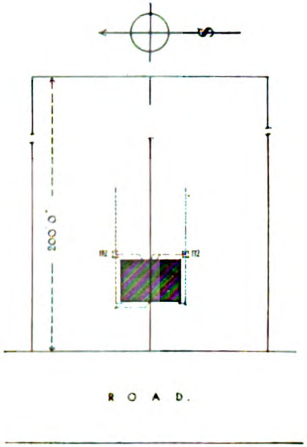
SCALE OF FEET





DETAIL OF EXTERNAL WALL

SCALE OF FEET



BLOCK PLAN

SCALE OF FEET.

ROOM	PRINCIPAL DIMENSIONS	SUPERFICIAL AREA	HEIGHT	CUBIC CONTENTS
KP	12 6 × 12 3	153·1	7·9	1186
Sc	9 0 × 8 6	76·6	7·9	593
B	12 4 × 9·6	132 0	8·0	973
B	11 7 × 7 1	82·0	8 0	618
B	8·6 × 8·0	68·0	8·0	501
L	6·4 × 2 9	17·5	7·0	122
W	5 6 × 2 9	15·1	7·9	117
CU. CONTS. 15091 @ 4d £251 10 4				

TABLE OF SIZES

DESIGN No. 238 ... BY R. I. McBEATH.

REINFORCED CONCRETE STATUES.

We are indebted to the "Concrete-Cement Age" for the following interesting description and illustration of reinforced concrete statues erected in the United States of America.—ED.

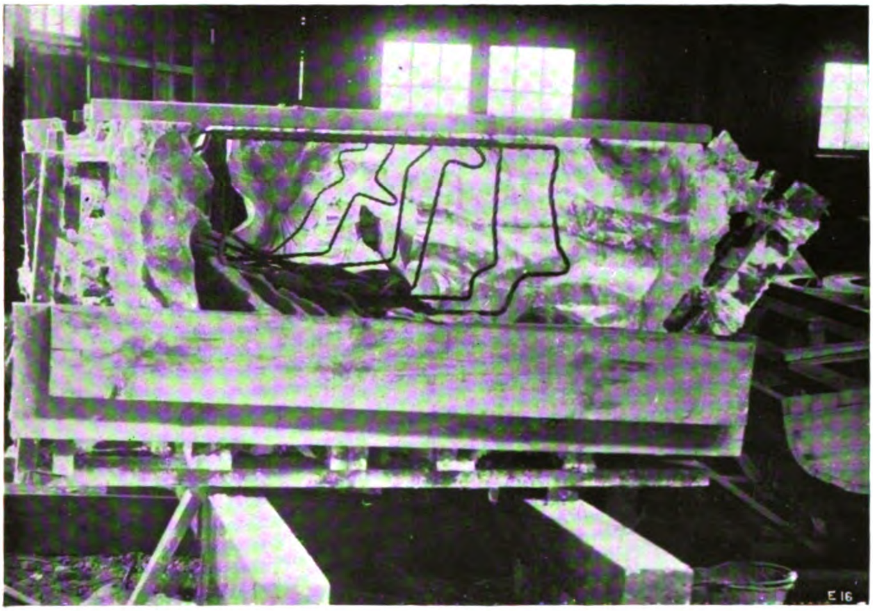
THE four great concrete statues which surmount the concrete cornice of the new Boston City Hall Annex are erected upon a building which is constructed, with this exception, entirely of steel and limestone.

The sculptor who designed and executed these statues is Mr. R. N. Burnham, and his work has been very favourably criticised. He made his study sketches and submitted 7-in. models, and then, working from these models, quarter-size plaster models were made complete in every detail, which furnished the dimensions from which the full-size figures were cast. Each of these figures is over 16 ft. high, and is set over 100 ft. above the side walk. They are semi-circular at the base and cut on a vertical plane up to the shoulders. That part from the shoulders down sets close to the limestone ashlar, while in each case the head pitches forward. All four are female figures draped in the Græco-Roman style, and they symbolise Charity, Industry, Education, and Law and Order. The figure of Charity is a mother holding her child; Industry carries the symbolic wheel in her right hand and in her left the Grecian distaff; Education carries the quill and book, and Law and Order the bundle of fasces (symbolic of the power of punishment bestowed on the Roman prætors) and the Book of Laws.

Some three months before delivery was required preparations were made (at the works of the New England Stone Co., Boston, U.S.A.) for the construction of the clay models. As each completed figure weighs approximately 8 tons, four small concrete floors, 8 in. thick, were put in 4 ft. below the ordinary floor level in order to bring the statues down to a more convenient level to work on. Platforms were placed so as to bring the models into a correct position relative to the arm of a pantograph to be used in reproducing them in full size. Special arrangements had to be made for heating and lighting, as on very cold nights, when it was impossible to keep up a full head of steam, there was great danger of the clay models being damaged by frost.

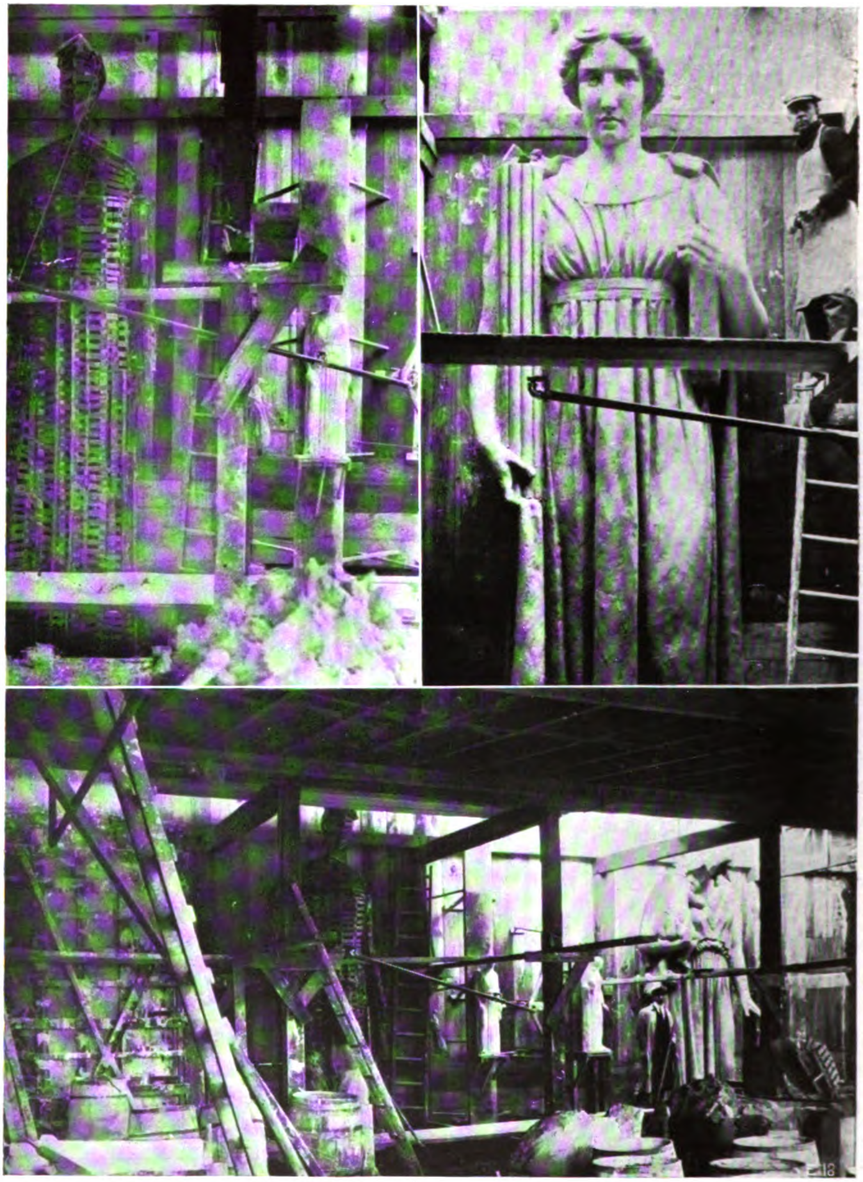
Modelling in Clay.—Immediately on arrival the first model was placed on its platform, and the enlarging machine began locating corresponding points on the small and large figures with a ratio of 1 : 4. As the points were located carpenters and modellers started the actual work by building a framework of 2-in. by 4-in. stock, strapping and laths. An attempt was made to keep the framework within an inch or so of the finished surface, and this was done fairly well, except in the draperies. The clay used in each figure weighed between 2 and 3 tons. The preparatory work was slow and very expensive, and when finished a rough covering of clay was thrown on, the figure then being handed over to the sculptor for completion. The final work was done by the hand, and with the modelling tool with a wire loop and a flat point, to bring out the fine details.

The Plaster Moulds.—As soon as the clay model was approved the plaster men started their work, the plaster being mixed quite wet in large dish-pans and then applied directly to the clay. The men began at the bottom and worked up, making a reverse mould with a minimum thickness of 6 in. As the plaster was applied strips of burlap were embedded in it for reinforcement. It was first planned to make the statue in four pieces, but it was later decided to build the body in one piece and the head separately. As each body was about 13 ft. high, a supporting cradle was necessary, one that would take all the stress incurred in moving the mould to its horizontal position for casting. The cradle was built of 2-in. by 4-in. and 4-in. by 4-in. spruce, strongly braced to resist torsion, and thoroughly attached to the plaster mould by several ties extending from the framework into the plaster shell itself.



Placing the wire reinforcement.
REINFORCED CONCRETE STATUES.

The mould dried in two days and then the clay and framework were ready to be removed. The head was taken off at a specially prepared joint running from shoulder to shoulder, where the draperies would help to hide any trace of it. The projecting feet were also removed. The plaster mould was then laid in a horizontal position. They were extremely heavy and cumbersome, and in grave danger of breaking when being tipped over. No matter how strongly they were braced there was always a certain amount of give to the wooden supports, and plaster, of course, is extremely brittle. Only one of them did

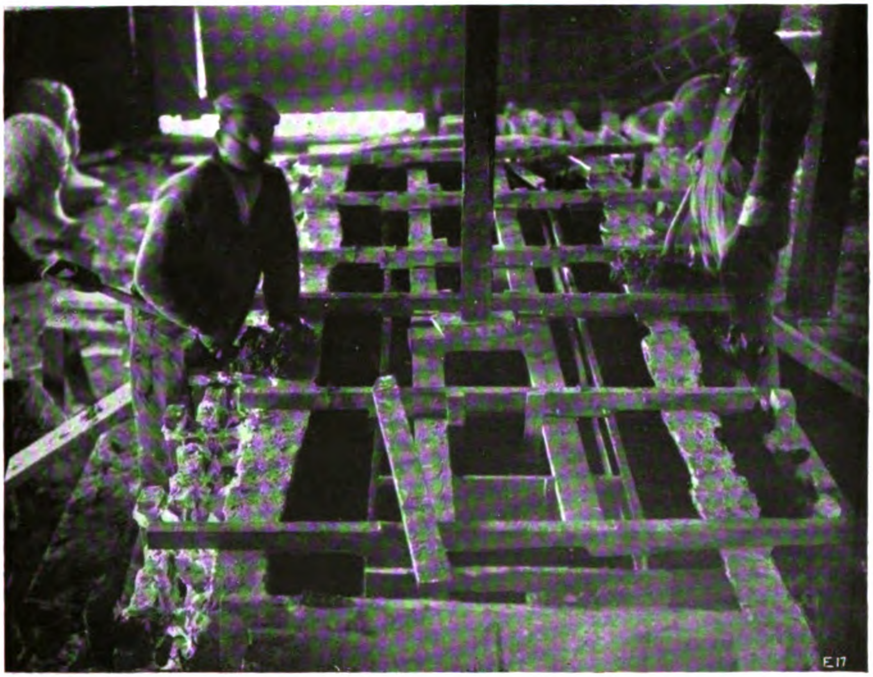


1. Skeleton frame being reproduced from quarter-size model by means of pantograph.
2. Finished clay model.
3. General view of workshop, showing (from left to right) plaster cast, skeleton frame, two quarter-size models, and a full-size clay model.

Reinforced Concrete Statues.

break, and this one sprung a vertical crack which caused several days' work. Jacks were utilised to push the sides together, the crack was carefully plastered, and the cradle practically rebuilt.

Placing Steel and Concrete.—When the mould had been placed in its horizontal position the inside was given two coats of orange shellac. The work of placing the steel was by no means an easy task, $\frac{3}{8}$-in. rods bent to conform to the draperies of the figure were placed at 8 ft. intervals, while through each vertical fold a $\frac{3}{4}$-in. bar was laid. At the back of the shoulders a heavy horizontal bar was put in, with its ends slipped into the looped ends of vertical rods on each side. Seven of the horizontal reinforcing rods were carried across the back to aid in resisting any force which might cause a vertical crack.

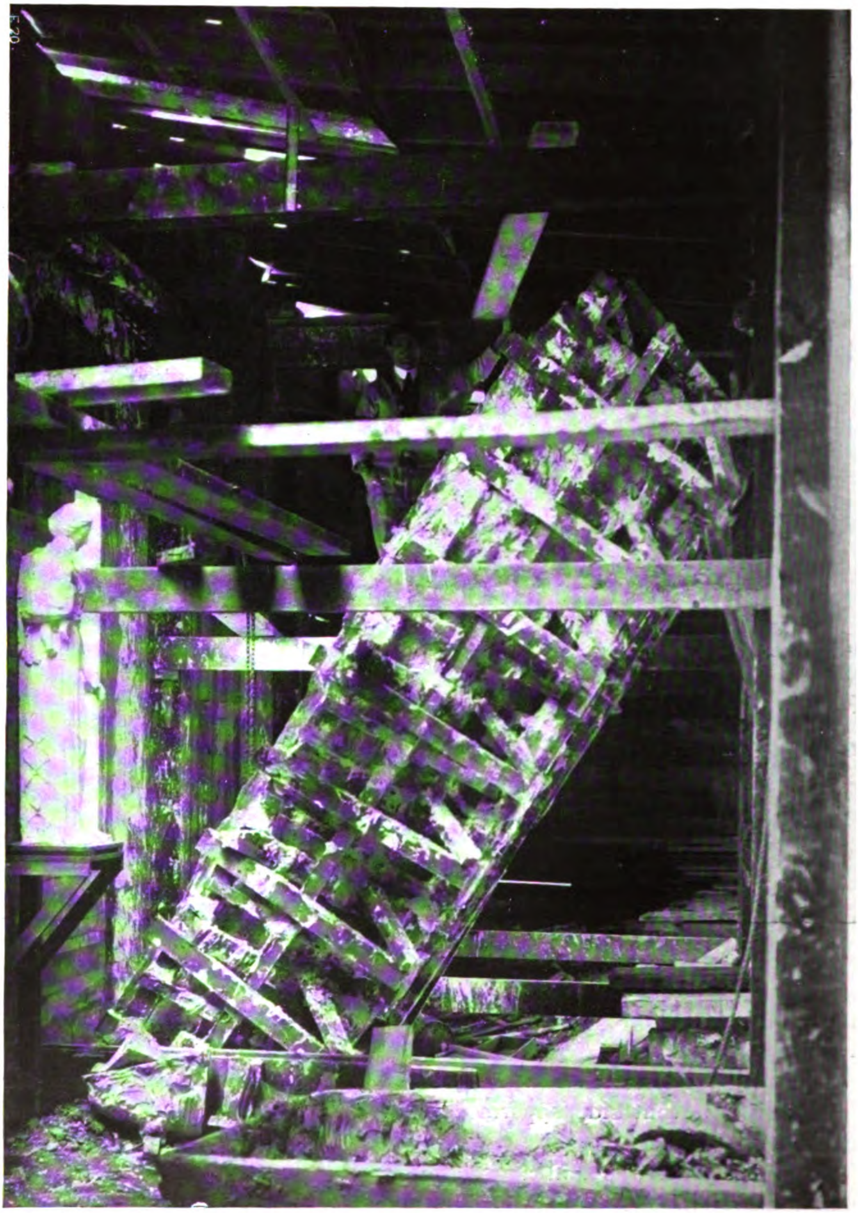


Placing and tamping the concrete.
Reinforced Concrete Statues.

This was important, as each concrete figure was turned completely over so as to bring the front side uppermost, and a break would have caused a very serious loss.

After the steel was laid a wooden core was suspended from bars on the top of the mould, and the core was firmly braced. Cores were carefully made so as to conform as nearly as possible to the shape of the mould, and at the same time allow a minimum thickness of 6 in. There were, of course, many projecting parts where the concrete was more than 1 ft. 6 in. thick.

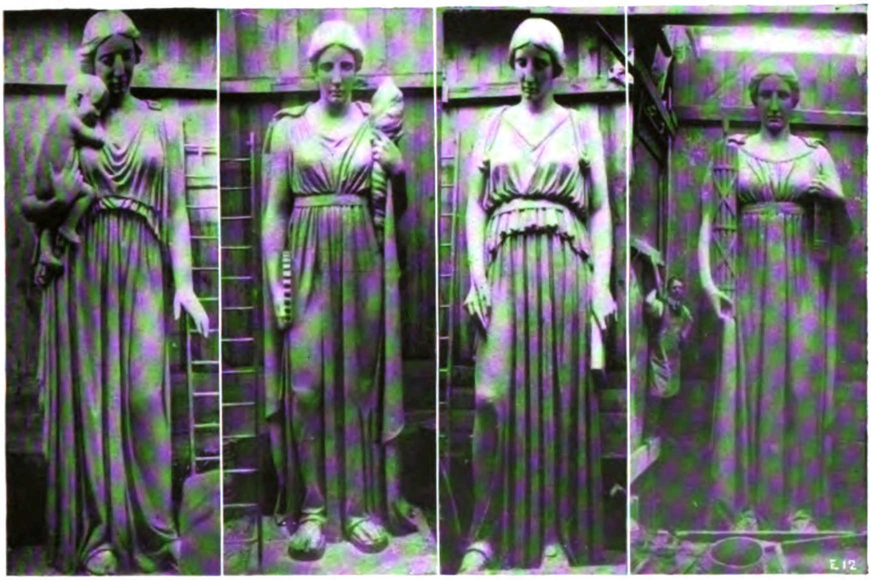
Much experimenting had been done in the effort to obtain a stone which would in every particular match the Indiana limestone ashlar. The cement, the sand, and the amount of lime used and the colouring substances all had their



Lowering plaster cast in cradle to horizontal position.
REINFORCED CONCRETE STATUES.

various characteristic effects. It was difficult to obtain a stone of fine enough texture and of the correct colour. The various combinations of mineral colours and cement gave very different results. Even after a satisfactory combination was found, the colour, particularly the red, gave a great deal of trouble, from the fact that different shipments of the colour varied slightly in shade. The final mixture of sand, marble, lime, cement, and colour gave a thoroughly satisfactory stone, which at a short distance could not be distinguished from the natural stone. The mixture had only one disadvantage—it was very slow setting.

Casting.—The casting of each figure took about fifteen hours of continuous work. The mixture was dumped into the mould as fast as two tampers could thoroughly work it into all the holes and crevices. The rough casting surface of the mould made this job a very slow one, as it was desired to produce a finished cast without any air-holes on the surface. The two tampers could work from inside the core and the mixture was well placed. As soon as it began to stiffen the slightest bit, as much as possible of a coarse 1 : 7 mixture was put in for backing. This was placed next to the core, as soon as it was certain that none of the coarser material would sink through to the face.



"Charity." "Industry." "Education." "Law and Order."

REINFORCED CONCRETE STATUES.

After casting, the figure was left alone for two weeks. At the end of this time the mould, with its concrete load, was turned right side up on to skids which ran out of the building, and labourers went to work with axes chopping off the plaster. This was a simple enough job, only requiring attention and care. When the concrete was stripped it was of a dark olive colour, this being the effect of the wet cement on the surface and the water still present. For another week the figure was sprayed twice a day, allowing the water to stand in the hollows whenever it would. In this way the danger of surface cracks, as far as they result from green concrete stone, was obviated. Three men then were set to work, under the direction of the sculptor, with hand stone-cutting tools and two automatic tools, carving out effects in the concrete, for this special concrete stone cut like limestone in every way. This tooling removed all the neat cement surface and made the stone safe against any cracking and subsequent discoloration.

Being on skids it was a simple matter to haul the huge 8-ton piece of stone on a truck to the City Hall, where it was swung up to its position.

There are two points of importance to be noticed in this job. First, that concrete stone should always have the surface which was next to the mould when cast removed by crandalling, bushing, chiselling, or rubbing; second, that concrete stone can be made, not successfully to imitate limestone or any other stone, but so as to produce a stone which is thoroughly satisfactory in appearance.

RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

RECENT PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE NATIONAL CONFERENCE OF CONCRETE ROAD BUILDING, U.S.A.

MIXING AND PLACING MATERIALS FOR CONCRETE ROADS.

The following Report was presented by Messrs. Paul D. Sargent (Chief Engineer, State Highway Commission, Augusta, Maine), Arthur H. Blanchard (Professor of Highway Engineering, Columbia University), and C. W. Boynton (Inspecting Engineer, Universal Portland Cement Co.).

In the construction of concrete roads, probably no really important part of the work is given less consideration, in specifications and in the field, than the actual mixing and placing of the concrete.

The following notes, based upon observations in the field, and the results of tests, were prepared with a view of pointing out the difference between good and bad practice, and to serve as a basis for recommendations covering this phase of the work.

The Mixer.—The concrete mixer should be of the batch type, provided with an automatic water tank, traction drive and power loader. Mixers having a boom and bottom dump bucket of sufficient size to convey one complete batch for placing the mixed concrete are preferred. However, buckets of other types and sizes, open troughs and revolving tubes can be used, and will give good results.

An abuse of the revolving tube distributing method lies in operating batch-mixers so equipped as continuous mixers, the supposition being that as the tube is provided with blades and revolves, the materials are mixed in the tube. This tube serves only as a conveyor and cannot to any degree take the place of or serve as a mixer.

Concrete cannot be successfully conveyed or delivered through a trough or spout through which it must flow by gravity, for if it is mixed to a consistency such that it will flow at the required angle, the concrete will be too wet for the best results.

The mixer should be provided with a suitable automatic water tank which can be quickly filled and emptied, so that when once determined, the required amount of water can be added to each batch of concrete. A number of so-called automatic tanks on mixers are not satisfactory owing to their limited capacity, delay in filling and emptying, and to the fact that they depend, for successful operation, upon a constant water pressure. Water is pumped on most road jobs with small gasoline or steam pumps, and it is not possible to maintain uniform pressure in the feed line.

An automatic measuring tank of the required capacity, that may be emptied quickly, connected by means of a comparatively large pipe with an auxiliary or storage tank of about 50 gallons capacity, would be more satisfactory than the one tank system commonly used.

Where necessary to keep from cutting up the sub-grade and to facilitate moving, the wheels of the mixer should be run on suitable planking. Material of good quality, 3 in. thick by 10 in. wide, in comparatively short lengths, with square ends, will be found satisfactory for this purpose.

The power loader or skip should be of sufficient size to hold all the materials required for the batch. In charging the skip a part or all of the coarse aggregate should be placed first, and the cement, fine aggregate, and remaining coarse aggregate, if any, on top of this. All the cement should be in the skip before the last of the aggregate is added. If charged in this manner there will be less tendency for the materials to stick in the skip when emptying and less loss of cement on windy days. A systematic method of loading the skip will also serve as a check on the right amount of material being placed each time.

The filling of the skip is accomplished in practice in two ways—by the use of wheelbarrows and by shovelling direct from the supply piles into the skip This latter practice, however, should be discouraged, for accuracy is impossible, and it encourages carelessness. Besides, the entire loading gang loses time waiting while the skip is raised and lowered.

Mixing Concrete.—No important operation is given less attention than the mixing of the concrete. Frequently in practice the time the materials remain in the drum is governed only by the speed of the gang charging the skip. At times the batch mixer is operated practically as a continuous mixer, by fastening the discharge scoop or spout so that there is a constant flow of concrete from the mixer.

The quality of concrete is largely dependent upon thorough mixing. To insure thorough mixing the revolutions per minute of the mixer and the time the complete batch, including water, remains in the mixer should be specified. To specify either the revolutions per minute or the time is not sufficient, as close observations in the field have shown.

Upon inquiry of the manufacturers it was found that the revolutions per minute of the drum of batch mixers varies for different makes and for different sizes of the same make.

Because of the shape and arrangement of the interior of the drum, the rate at which a given mixer is operated has a direct bearing upon the quality of the concrete, therefore the drum should be operated at approximately the speed at which the manufacturer claims the best results would be obtained.

It is recommended that all specifications contain a clause to the effect that all the materials in any one batch—including the water—should remain in the drum of the mixer at least 45 seconds before any of the concrete is discharged.

In all cases the drum should be completely emptied before the next skip of materials is dumped into the mixer. This is a source of constant controversy between the engineer or inspector and the contractor, especially where the mixer used is equipped with an open trough, or with a boom and bucket when the bucket is not large enough to hold the whole mixed batch.

The operator should start the water into the drum as soon as the skip is in position to dump—that is, it is not necessary to mix materials dry before adding water.

Consistency.—The practice on road work is to mix concrete entirely too wet. This causes a separation of the coarse materials from the mortar, resulting in stony pockets throughout the concrete. Where the concrete is mixed too wet, it is practically impossible to obtain and hold the required crown, and stony patches frequently appear on the surface after it has been finished, owing to the flow of water and mortar to the sides. In striking off and floating concrete mixed with an excess of water, it is also practically impossible to obtain a surface of the desired character, as the excess of water collects in and hides depressions and other inequalities in the surface, which cannot be corrected as they are not apparent until after the water has evaporated.

In addition to the difficulty encountered in getting wet concrete into the pavement in a manner which will give the best results, laboratory tests and results observed in the field show that, other things being equal, a wet mixture is of inferior strength and quality to concrete of a medium wet consistency. The marked effect in the strength of concrete that a variation in the consistency produces is shown in the following table of results of tests made in the Sheffield Scientific School of Yale University by Chas. J. Robinson :

Per Cent. Water.	*7 Days†.*	*30 Days*.*	*60 Days†.*
20	2,052	2,777	3,194
22½	2,173	3,132	3,305
25	2,277	3,278	3,388
27½	2,500	3,516	3,597
30	1,722	2,874	3,166
32½	1,413	2,416	2,666
35	1,222	1,977	2,388
37½	1,097	1,819	2,173
42½	652	1,500	1,888

**Average of two tests.* *† One test only.*

In this test water was added from 20 per cent. to 42 per cent. according to the following method :

"As a minimum, enough water was taken to moisten the stone and sand, and then there was added 20 per cent. (of the amount of the cement by weight) water. Each subsequent mixture was increased by 2½ per cent. water. It was noted that the 42½ per cent. mixture was about as wet as is used in the average wet mixture, though drier than some slushy mixes."

As yet there is not sufficient data on which to base a definite conclusion relative to the influence of the consistency of concrete upon the expansion and contraction; however, information at hand seems to show that this action is influenced very largely by the consistency.

Owing to the methods employed in striking off and finishing the surface of concrete pavements, there is little likelihood of mixing the concrete too dry. Concrete mixed with an excess of water is easier to mix, to handle, to place and to finish, than concrete of the proper consistency, which explains the tendencies toward wet mixtures.

The amount of water in the concrete should be such as to cause it to settle to a flattened mass when dropped from the bucket, but not sufficient to cause it to flow readily on the sub-grade. The consistency should be such as not to require tamping, but not so wet as to cause a separation of the mortar from the coarse aggregate in handling and placing. If there is an excess of water on the surface, or the mass has a tendency to flow or settle out of position after being floated, the concrete has been mixed too wet.

Placing Concrete.—Just before placing concrete the sub-grade should be well sprinkled so that it will not absorb moisture from the concrete, and should be checked by the engineer or inspector to make sure that the required thickness of concrete can be placed. Checking the sub-grade may be done by the use of a straight edge or line, resting on, or stretched from, the top of the side forms.

Probably the most satisfactory method of depositing the mixed concrete in position on the sub-grade is by means of a bottom dump bucket running on a swinging boom from the mixer. The boom can be swung over any position on the sub-grade, and the bucket can be run out and dumped at any point along the boom. Such equipment does not depend for economic operation upon consistency, and the concrete can be easily handled and deposited at any place on the sub-grade, necessitating but little handling with shovels. Between each change in position of the mixer a section the full width of the pavement (up to 1½ times the length of the boom), and as long as the boom, may be concreted.

When concrete is placed by means of the open trough care must be exercised to see that it is not mixed too wet, as this method of distribution depends for economic operation very much upon the consistency of the concrete. An open trough is necessarily much shorter than a boom and is more limited in action, which requires that the mixer be moved ahead more often, also that more of the concrete after being deposited on the sub-grade be handled with shovels.

When a batch mixer not having a boom and bucket or open trough is used, the concrete should be handled in wheelbarrows or handcarts wheeled on suitable runways. Placing concrete by means of horse carts should not be permitted, as they cut up the sub-grade badly, and to get the concrete into final position requires a maximum amount of shovelling.

Whatever the method of conveying and placing, the concrete should be deposited upon the sub-grade to the required depth and for the entire width of pavement in as nearly one operation as practical so as to reduce handling to a minimum. If it is necessary to handle a large amount of material with the strike-board it will ride the concrete, and thus produce a wavy, uneven surface. Attention to this matter will materially lessen the difficulty and labour in striking off the surface and will result in a very much better finish.

The excess of coarse material that accumulates in front of the strike-board should be uniformly distributed over the surface of the pavement, and not left in narrow strips across the section, or placed along transverse expansion joints. An ordinary garden rake will be found useful in distributing the material that accumulates in front of the strike-board. When the strike-board is within two feet of an expansion joint the excess material that has accumulated in front of it should be removed with a shovel and deposited on the sub-grade in the next section. Special care should be taken to place good dense concrete along expansion joints, and all inequalities at the joints, including any small holes left after the removal of the installing device, should be filled with a mortar composed of one part cement and not more than two parts fine aggregate.

The man handling the strike-board should follow closely behind those placing the concrete, for keeping up with the strike-board will materially assist those placing concrete in depositing the required amount of material.

The placing of concrete should be a continuous operation, and stops should be made only at expansion joints. In case the mixer breaks down concrete should be mixed by hand to complete the section, or an expansion joint should be placed at the point of stopping work. Any concrete in excess of that needed to complete the section, when work is discontinued, should be spread out in a thin layer, not exceeding 2 in. in thickness, over the sub-grade in the next section and not piled up along the expansion joint.

The strike-board should be cut to conform to the crown of the finished surface of the pavement and should be of sufficient strength and stiffness to show no deflection at the centre when supported at the ends, nor a material bowing out of alignment when in use. It should be about 2 ft. longer than the width of the road, protected on the bottom edge with a metal facing and provided at each end with suitable handles.

For roads up to 12 ft. in width two 2-in. by 6-in. planks, dressed on one side and both edges, spiked together, make a good strike-board, and for roads 12 ft. to 20 ft. in width two 3-in. by 8-in. or a 2-in. by 10-in. and a 3-in. by 10-in., spiked together, will be found satisfactory. Two planks, well spiked together, make a better strike-board and one less likely to warp out of shape than a single piece. The strike-board should not be so heavy that it cannot be easily handled by two men, and to reduce weight and increase stiffness, it is advisable for work over 20 ft. in width to use a strike-board composed of boards 2 in. or 3 in. thick, stiffened by trussing, rather than obtain the required stiffness by the use of heavier timbers.

In striking off a pavement 16 ft. or less in width, where the concrete has been properly placed, two men should be able to handle the strike-board, but for wider pavements the services of a third man will be required to assist in pulling the board forward by means of a drag line fastened at its centre.

The strike-board should always be worked forward about perpendicular to the axis of the roadway, and as it is moved ahead should be sawed back and forth across the road.

To produce the desired effect will require that the strike-board be passed over the surface of the concrete two or more times.

Though it will be necessary for the workmen to get into the concrete some time after it is deposited on the sub-base, it is desirable that all unnecessary walking in and wading through the concrete be avoided, and under no circumstances should any workmen step upon the concrete after it is first struck off.

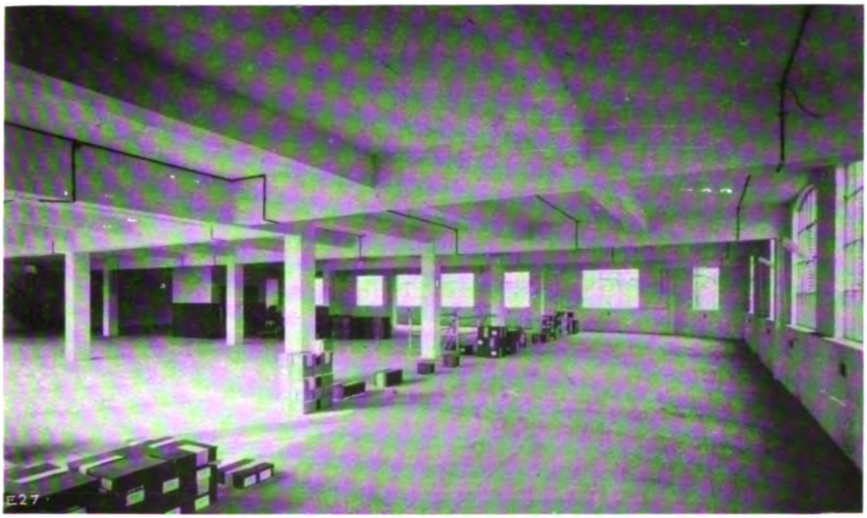
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE PAPER WAREHOUSE.

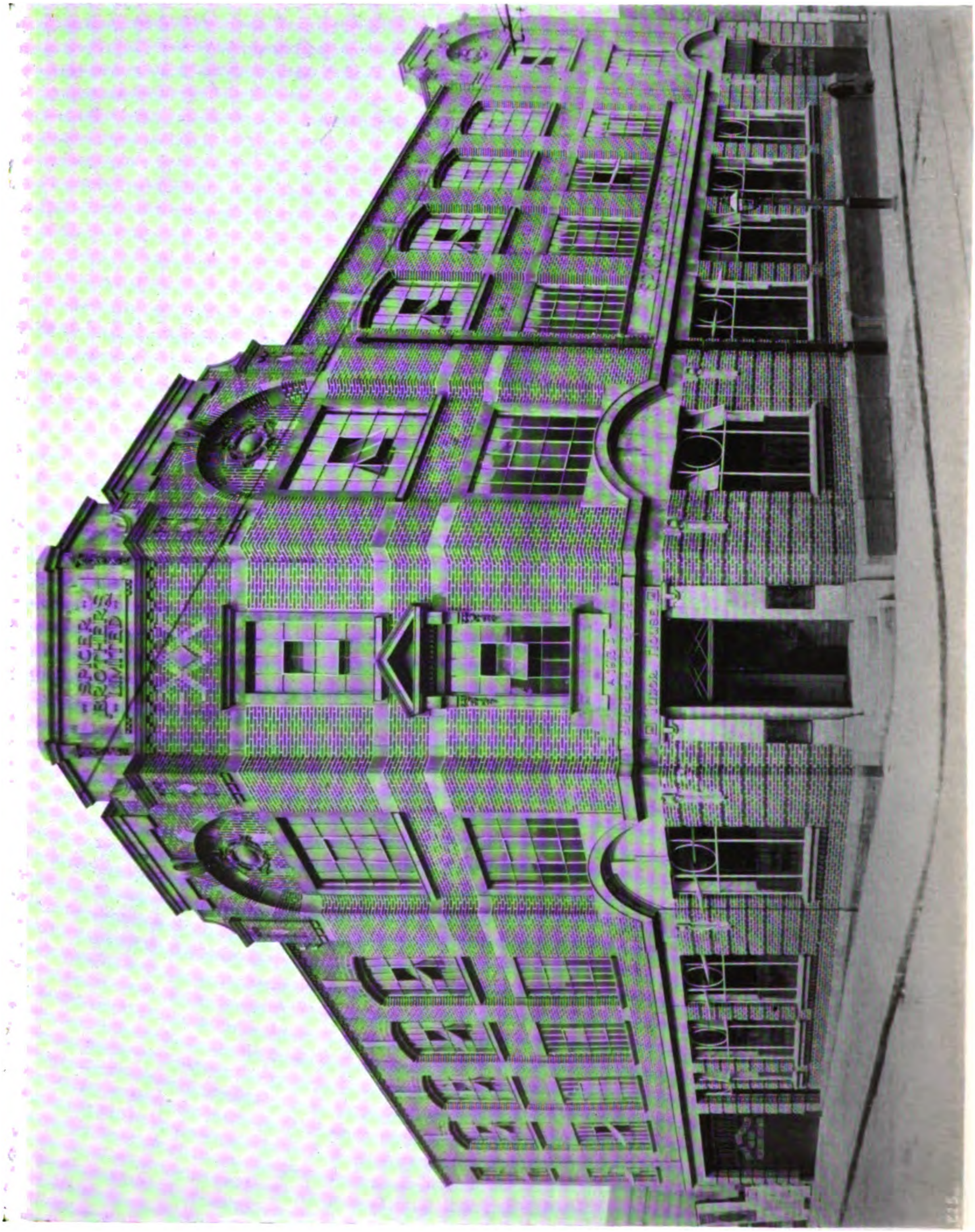
A HANDSOME building has recently been constructed in Birmingham on the corner of Cornwall Street and Livery Street. This new warehouse, which goes under the name of Tudor House, has been constructed almost entirely of reinforced concrete on the Coignet System, to suit the requirements of the increasing business of Messrs. Spicer Bros., Ltd., the well-known stationers and paper manufacturers. The entire work was carried out in accordance with the plans, and under the general supervision, of Mr. Marcus O. Type, F.R.I.B.A., architect, of Birmingham.



Interior View.
REINFORCED CONCRETE PAPER WAREHOUSE, BIRMINGHAM.

As shown in the accompanying illustration, the two principal elevations of the building have been constructed in brickwork. The external walls have a thickness of 9 in., and the inner walls are 4½ in. thick, and a cavity of 2½ in. has been left between the inner and outer walls. Reinforced concrete lintels have been provided throughout the structure over all windows and doors. The building, which is of an irregular shape, occupies a space of approximately 80 ft. by 95 ft.

There is a ground floor, first floor and second floor, and a flat roof, and the latter has been designed sufficiently strong to form another floor, to provide for future extensions. The first floor is calculated for a super-load of 4 cwt. per sq. ft., and the second floor and roof are calculated for a super-load of 3 cwt. per sq. ft. All these

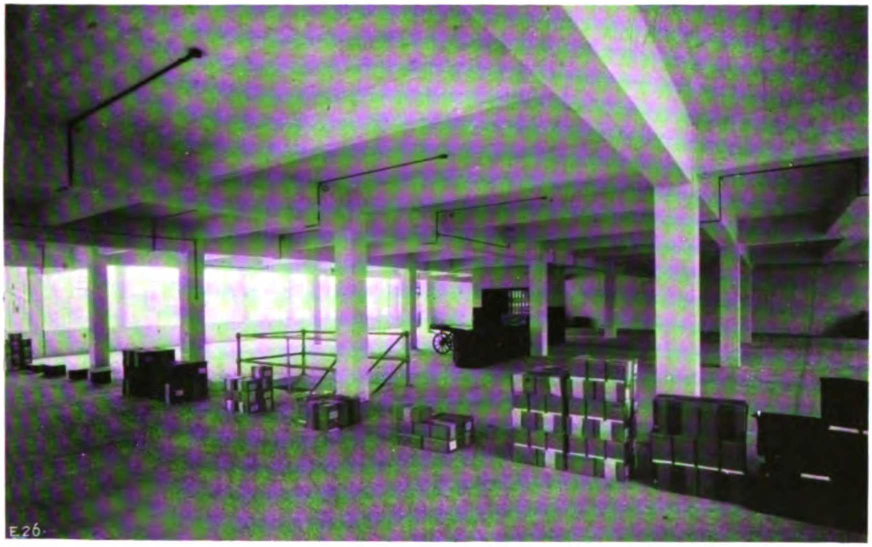


View Showing Completed Building.
Reinforced Concrete Paper Warehouse, Birmingham.

floors are entirely supported by reinforced concrete pillars and footings, so that the weight of the floors is not carried by the brick walls. In fact, the brick walls are constructed in such a manner that they are supported on each floor by the reinforced concrete lintels. The pillars supporting the first floor have scantlings of 18 in. by 18 in., those supporting the second floor are 16 in. by 16 in., and those supporting the roof are 14 in. by 14 in. As all the floors are required for the storage of heavy goods, which are conveyed from one place to another by means of trollies, the surface of each floor has been covered by means of granolithic paving having a thickness of 1¼ in.

The arrangement of the various members of the structure, pillars, beams, and slabs has been devised in the most economical manner, the entire area of the building being cut up into rectangular bays measuring 14 ft. 9 in. centres by about 23 ft. 7 in. The main beams on all floors are 12 in. by 23 in. measured from the under-side of the slab, and secondary beams have scantlings of 9 in. by 14 in., and the thickness of the slab is 5¾ in. on the first floor and 5¼ in. on the second floor and flat roof.

As shown in the photographic illustrations, the interior of the warehouse is simply whitewashed, and large windows have been provided in order to obtain the maximum amount of light. These showrooms and offices have been specially designed for the rapid and efficient handling of orders and enquiries.



Interior View
REINFORCED CONCRETE PAPER WAREHOUSE, BIRMINGHAM.

Reinforced concrete is, of course, eminently suitable for a warehouse of this description, where a large amount of paper is to be stored. It is fire-resisting, and it offers the considerable advantage of being extremely clean and durable; and in a building like this, where the loads on the floors are very heavy, it commends itself for its economy over all other forms of construction.

The whole of the reinforced concrete work was carried out by Messrs. Richard Fenwick, Ltd., of Birmingham, licensees of the Coignet System, who have already constructed a number of important buildings on this method.

A REINFORCED CONCRETE BRIDGE IN JAPAN.

THERE has recently been erected at Yoshida, Japan, a reinforced concrete bridge, of which we are able to present the accompanying illustrations.

The bridge, on completion, was submitted to a load test, and satisfactorily withstood the test without any crack or break appearing in the structure.

The details of the concrete slabs utilised may be noted in *Fig. 2.*

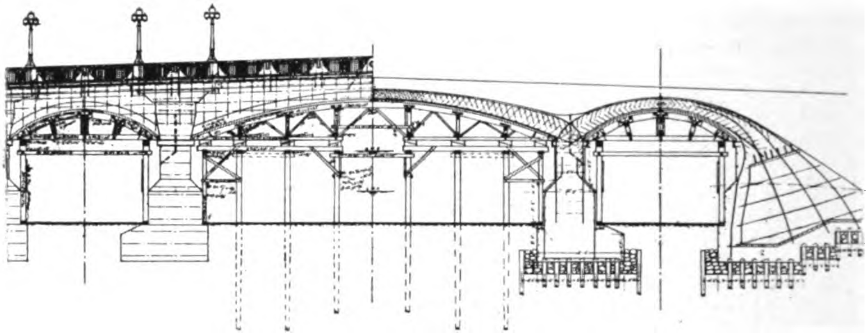


Fig. 1. Elevation.

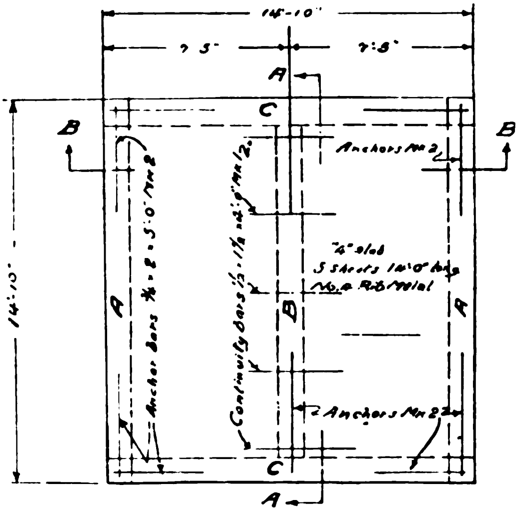
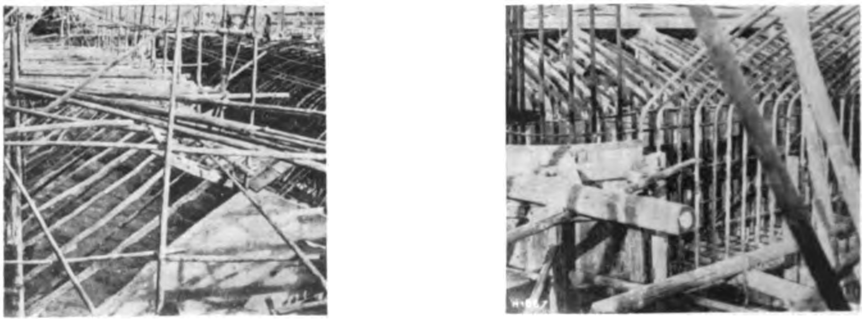


Fig. 2. Plan of Concrete Slab.



Figs 3 and 4. Showing Reinforcement.

REINFORCED CONCRETE BRIDGE, YOSHIDA, JAPAN.

There were five sheets of four-rib metal used in the top, and there were ten anchor bars employed measuring $\frac{3}{4}$ in. by 2 in. and 5 ft. long, and five continuity bars $\frac{1}{2}$ in. by $1\frac{1}{2}$ in. and 4 ft. in length.

The concrete slab used measured 14 ft. 10 in. square, divided in the centre by a beam (*B*) measuring 12 in. in width and 16 in. in height. The thickness of the top of the concrete slab was 4 in., reinforced with five sheets of four-rib metal, as stated above. The reinforcement in the concrete beams *A* and *C* was similar to that in the centre beam (*B*), but the outer beam (*C*) was 18 in. high and 12 in. wide, while the concrete beam *A*, as in the case of the centre beam (*B*), only measured 16 in. in height and 12 in. in width. In addition to the above reinforcement, there were used ten bars 1 in. by 3 in. and 14 ft. 6 in. long, also three bars $\frac{3}{4}$ in. by 2 in. and 14 ft. in length.

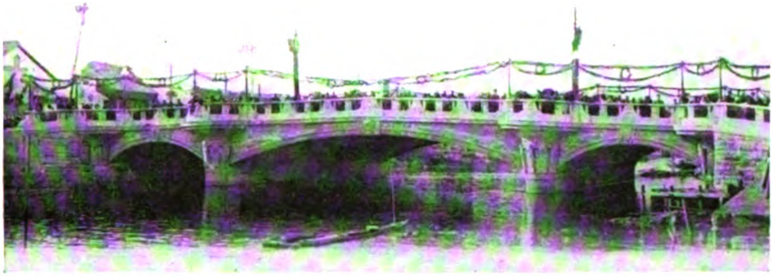


Fig 5. Completed Bridge.

REINFORCED CONCRETE BRIDGE, YOSHIDA, JAPAN.

INDUSTRIAL NOTES.

The following are some notes regarding Concrete Mixers, Block-making Machines, and Grouting Machines manufactured in Great Britain.—ED.

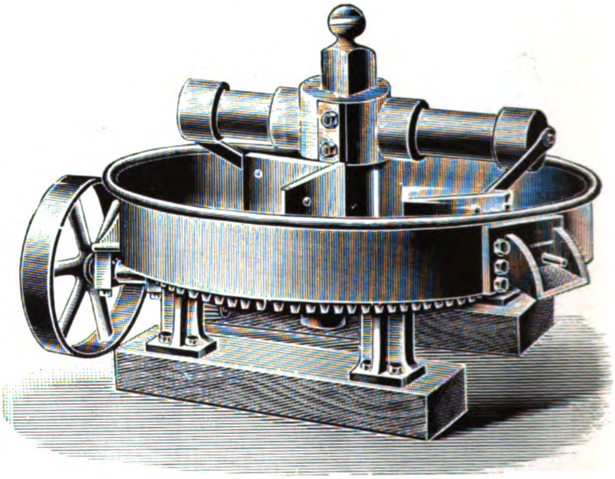
At the moment when so many of the Continental markets are to all practical purposes closed, it may not be inopportune to present the subjoined notes regarding a number of firms who can supply concrete machinery and other concrete-making appliances actually manufactured in Great Britain. This is probably not only of use to our readers at home, but in the Colonies, where there is an ever-increasing use of concrete in every form for large buildings, railway work, road work, estate work, etc.

As stated above, the present article deals with concrete mixers, block-making machines, and an air compressor and grouting pan.

In a later number we propose dealing briefly with smaller appliances, such as tools and moulds.

Mason Bros.—This firm manufactures both a continuous mixer and a batch mixer.

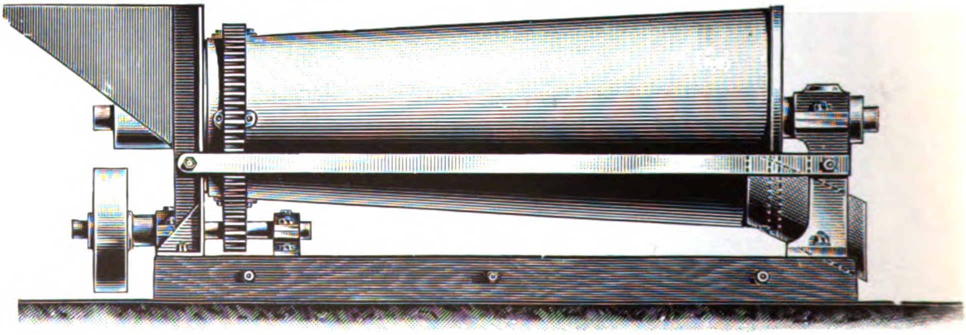
Pan Batch Mixer.—A pan varying from 4 ft. 3 in. to 7 ft. in diameter forms this batch-mixing machine; the depth of the pan is 12 in., or deeper if desired, and it is fitted with a false bottom, which is cemented in.



There are three or four steel mixing blades, according to the size of the pan; these are fixed to a cross arm which is made to revolve. The centre shaft takes its bearing on the boss of the pan, and turns the arms and mixing blades, the shaft being keyed to a large bevel wheel under the pan.

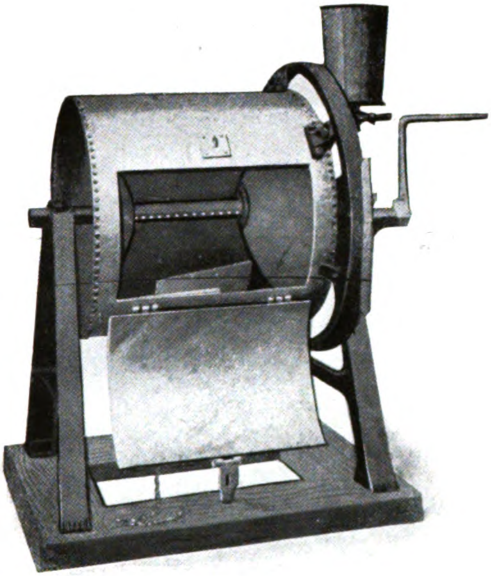
Our illustration shows the mixer and the pinion and pulley by which it can be driven. The machine, by the addition of two rollers, can be converted into a grinder or mortar mill.

The Continuous Mixer is very simple in construction. It consists mainly of a long tapering cylinder, varying from 7 ft. to 9 ft. in length and 2 ft. 6 in. to 3 ft. in

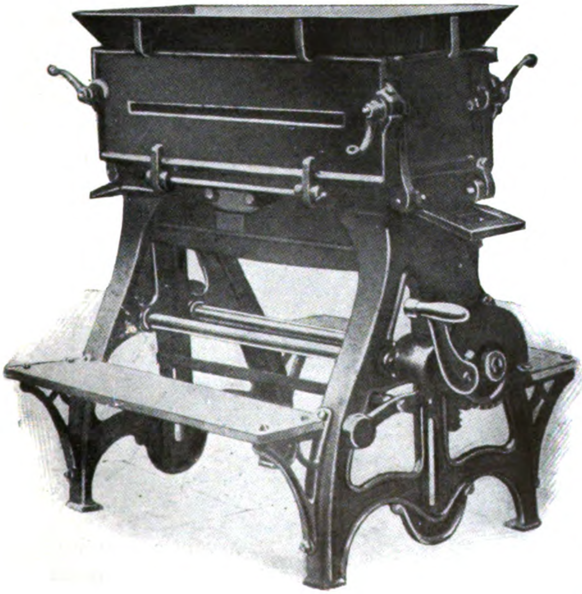


diameter at the mouth. The cylinder is fitted internally with ribs and made to revolve. It is fed through a hopper at the narrower end, and the water is provided by fixing a water pipe down the hopper with the tap turned into the cylinder, the flow being then gauged by the tap as desired. This machine may be driven either by hand, steam, or electric power, by an ordinary cross-belt drive. It produces about 9 cub. yd. of concrete per hour.

Concrete Machinery Co. —The *Pioneer* Portable Batch Mixer is very simple in construction. The several wings inside the drum convey the materials to the top of the drum and discharge them against the slopes of the two cones, down which they slide, and the two streams of materials are thus being thoroughly and constantly intermingled.



The No. 1 *Pioneer* machine for making hollow building concrete blocks is worked by hand-power only. It is portable, and makes straight blocks, 32 in. × 10 in. × 9 in., three-quarter, half, and quarter blocks; also corner, joist, and bay window angle blocks; no change of the machine requiring more than ten minutes to effect. The outside face of the blocks can be made "chiselled and ashlar" or "rock face," as desired, and the inside face is made ready for the plaster.

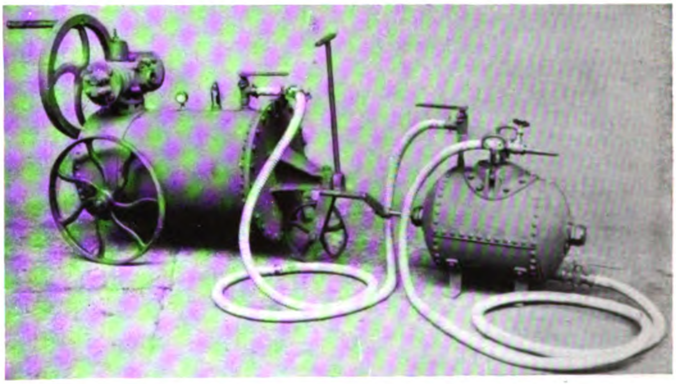


A feature of the machine is its portability, allowing the builder to remove it from site to site, just as required. The blocks have cavities, which not only effect a saving in material, but render the blocks lighter to handle, and, owing to the combination in the machine securing the cavity from the foundation to the eaves, thus bringing about a dead air space, it results in the building being cooler in summer and warmer in winter and more damp-proof.

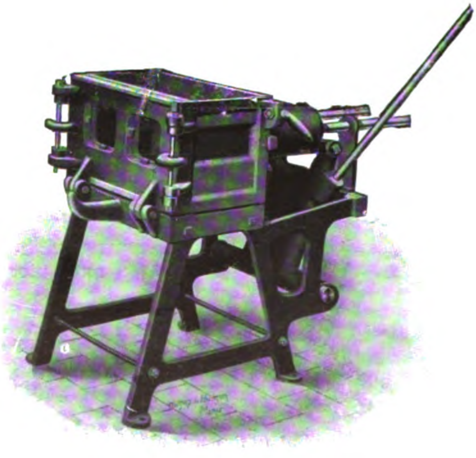
The *Pioneer Junior* machine is similar in construction to the above, but turns out blocks of a smaller size—namely, 20 in. × 10 in. × $6\frac{1}{2}$ in.

Murray, Workman & Co., Ltd.—*Air Compressor and Grouting Pan, portable plant for renewing foundations, repairing bridges, tunnels, walls, etc.*—The air compressor is of the duplex single-acting type, arranged on air receiver, and for portability is mounted on wheels with castor-wheel and draw-handle in front. Receiver has safety valve, pressure gauge, and drain cock; also a stop valve with coupling tail for rubber hose connection to pan. The grouting pan is a cylindrical vessel about 18 in. diameter by 2 ft. 6 in. long, being fitted with large hand-hole opening having clamp-down lid with rubber joint. There is a steel spindle which passes right through the pan, and it has a series of stirrers mounted on it in such a way as will maintain a thorough mixture. The ends of spindle are rendered tight by stuffing boxes.

Operation: After the hose pipes have been connected between air receiver and pan and grout pipe provided with suitable nozzle for work, cement, sand and water are filled into pan and the lid is made secure with clamp; grout now becomes thoroughly mixed by turning handle. Meanwhile, the receiver can be pumped up to 30 lb. per sq. in., and it is now ready to inject the grout or cement into spaces where desired. Care should be taken to keep the end of pan next grout-cock a few inches lower than the other end, so as to ensure the complete discharge of grout. Air should not be allowed to escape with the grout, or the work will not be sound. Every pound of air pressure on gauge is sufficient to raise the grout up 2 ft., and as the grout will tend to flow the easiest way to escape, it follows that all cracks or holes must be surface-stopped before grouting proceeds.



Pickles & Son, John.—This firm make a portable batch concrete mixer for hand mixing; also machinery for sewers and drain pipes, as well as cement and sand bricks, etc., machines.



The *Holcrete* machine, as its title implies, is devised to make hollow concrete blocks. The machine is simple in construction, portable, and easy to manipulate. It is operated by hand power. The blocks are moulded face down, and the machine has a capacity of 200 blocks in ten hours. By the aid of different accessories the machine will also turn out solid or hollow blocks for corners, bay window angles, sills, water tables, circles, or octagons.

They also supply moulds for concrete fence posts, flags, telegraph and telephone posts, sleepers, pit props, etc.

The (U.K.) Winget Concrete Machine Co., Ltd.—The *Winget* hand mixer is constructed of steel, cast iron, and brass. The machine is simple in construction throughout, and is easily worked and understood even by unskilled workmen.

It consists of a strong frame supporting a mixing pan suspended from the main shaft, and partly rotating thereon, secured in position by catch and tilted by a lever. The main shaft carries mixing blades and scrapers to keep end of mixing pan clean. The main shaft is rotated by simple gearing and winch.

The combined measuring hopper and shoot is pivoted to the back of the frame, and is elevated to such an angle that its contents are shot into the mixing pan. It is partly covered in, so that cement is not blown out in windy weather.

The hopper is elevated by means of wire rope coiled on to sheave of top shaft, which is operated by pitch chain actuated by sprocket wheels and hand wheel on opposite side of mixer to gear wheels and winch. To allow of the hopper being worked expeditiously, a counterpoise balance weight is provided, suspended in a W.I. tube by wire rope, which is coiled on to another sheave mounted on the top shaft. In the inside of the hopper are arranged a series of V-shaped deflector plates, so arranged that as the material in the hopper gravitates to the pan it is partly mixed dry. The sparge pipe is supplied from a tank, which receives its supply from a ball-valve.

The supply of water to the sparge pipe is controlled by a cock, the key of which is so arranged that by a simple combination of levers the ball-valve is closed to prevent the entry of water to the tank during the time it is passing from tank into sparge pipe. A float and indicator show, by means of a scale outside the tank, the quantity of water discharged when cock is opened, thus giving a positive quantity, as no water is allowed to enter tank during the time of discharge.

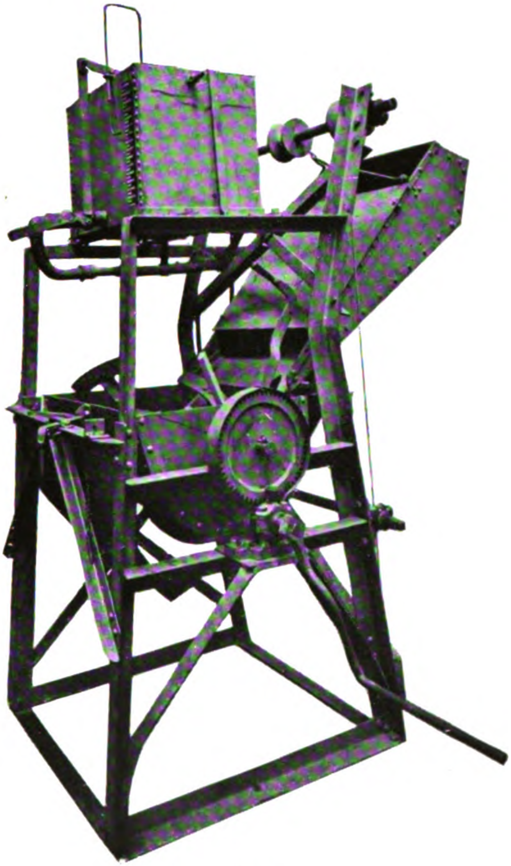


Fig. 1.

There are no figures on the scale, as in practice the instructions given are that so many divisions of water are to be discharged for each batch. The index weight thus can be made to count from any position. Should the aggregate vary as to its dryness, the number of divisions to be discharged is altered.

The *Express* mixer is driven by power, and the illustration gives a general view of the machine and shows the gearing under the pan; this gearing and pulleys, and the capstan carrying the arms, show how few are the wearing parts of the machine and its extreme simplicity. Ease of fixing is another feature, as all the foundation requires is a flat bed of concrete—say, 8 in. to 12 in. in thickness—with the bolts for securing the machine embedded, or the machine may be fixed to a pitch-pine underbed.

The machine consists of a pan 6 ft. 6 in. diameter and 1 ft. 9 in. deep. The capstan is keyed on to the vertical shaft, driven by mitre-gearing, and carries arms revolving over the pan, to which are attached adjustable, plough-shaped beaters, and each plough carries in its rear an iron rake. The action of the machine is to imitate

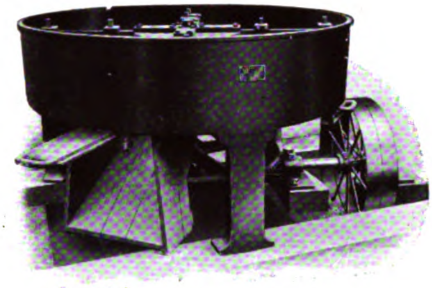


Fig. 2.

hand mixing, but the number of times the materials are turned over in the pan is very much greater. This is attained by the ploughs turning over the material, and the rake immediately following raking it out ready for the next succeeding plough to turn over.

In use the machine is set revolving, and the cement and aggregate are dropped from a hopper into the pan. After the materials have been mixed dry for, say, fifteen seconds, the water is added, preferably by means of a circular spray pipe fixed over the machine and supplied from an automatic measuring tank. The material is now mixed for, say, twenty-five seconds, and one of the sliding doors in the bottom of the pan drawn, and the mixed concrete is delivered on to the ground or into barrows or as desired. The *Express* mixer will mix either dry, semi-dry, or wet. The mean power required to drive is about 6 b.h.p., including counter-shafting.

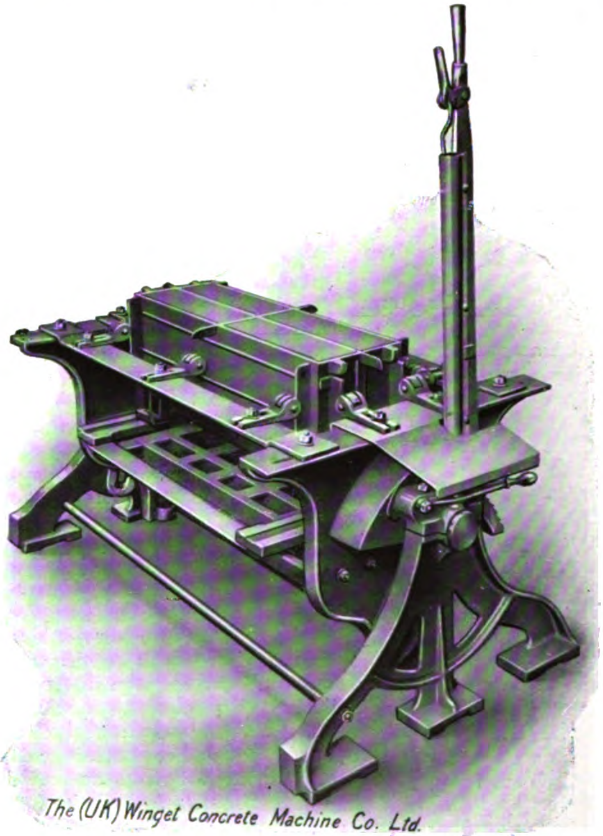


Fig. 3.

False sides and bottom are fitted to the pan, which can be easily replaced when worn, and the ploughs and rakes are renewable. Being of the open-pan type, the machine is accessible in every part for cleaning out, and does not clog up.

The *Winget Concrete Block-Making Machine* is very simple in construction, all movements being controlled by one long lever.

Fig. 3 illustrates the machine, which consists of a mould box with hinged sides and ends, carried in the machine frame (which is of a standard pattern) and hung in trunnions, as shown, with core blocks and division plates set inside. When the lever at the right hand side of the illustration is pulled down the bottom of the mould box (which is formed with a loose pallet inserted for each block) is lifted up, and at the same time the sides of the box fall outwards, leaving the finished block or article on the pallet ready to be taken off.

Only two motions are required to open and close the machine.

The machine can be used if required in a face down position, also for the manufacture of three thin partition slabs keyed all round on one pallet at one time and at one operation.

This machine can be worked by unskilled labour, which means considerable economy in wages and operating costs, and the simplicity in the working adds to the speed in obtaining output.

The change of face-pattern, type or size of block is quickly effected, and the machine can be altered to produce two or four up to ten blocks at a time, plain or patterned texture of face, all parts being interchangeable.

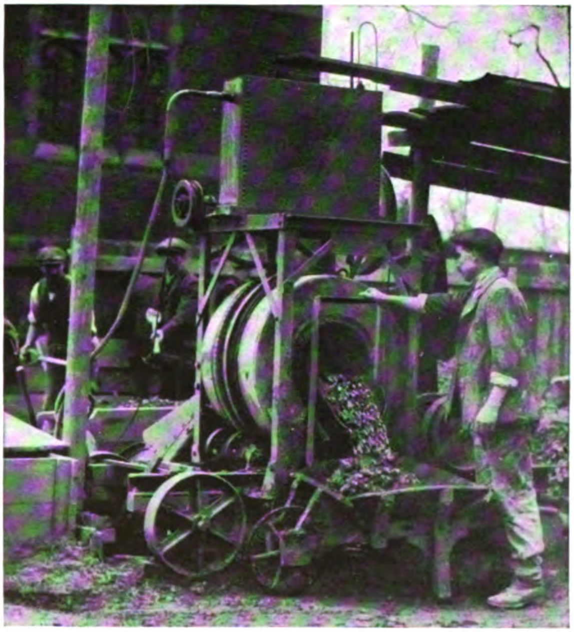
Each machine is a complete plant in itself; it is portable and no power is needed. All sizes of hollow and solid blocks and specials are within its capacity (32 in. by 16 in. by 9 in.), and it makes, with division plates, four separate blocks at a time. With special accessories the following can be made: moulded and plain coping, plinth, string courses, label moulds, garden edging, kerb and channel, air ducts, agricultural field drain pipes, bricks, flooring tiles, arches for coal mine roofs and pit props, etc.

Smith, T. L., & Co.—The *Victoria Mixer* is designed to produce two fundamental elements of good mixing: first, a constant turning of the batch; second, a continual lateral interchange of materials between the ends of the drum.

The Victoria drum is a cylinder with four deflecting surfaces or inclined planes. Lifting blades are riveted into the drum, extending from the discharge end well towards the feed side. These lifting blades raise the ingredients, which drop upon the inclined planes. Because of the angularity of these surfaces, the falling materials are thrown across the drum, to be returned again by the opposing deflectors. This complex process, repeated twice for each revolution of the drum, subjects the mass to twelve distinct mixing actions per turn of the drum.

Feed: In this mixer the materials, on leaving the feed spout, fall upon the deflecting surfaces, which turn over, fold, and twist the mass. The feed is necessarily very fast, as there is a vertical fall of the materials from the feed chute.

Discharge: The time saved by a rapid mix may easily be lost in emptying the drum. The rate of discharge, therefore, ranks second only in importance to the speed of mixing. To empty the mixer, a swinging spout pivoted below the discharge opening is projected into the drum. The mass falls from the blades



upon this discharge spout or chute. The chute stands at a steep angle, assuring a rapid flow of the concrete into the wheelbarrows or carts.

Control: The flow of concrete from the mixer is under accurate and easy control. Any quantity of concrete can be measured into wheelbarrows, carts, or other means of distribution.

Two valuable attachments to this mixer are the Victoria side loader and the automatic water tank.

Ransome-verMehr Machinery Co., Ltd.—The *Ransome Mixer* (of American origin) was introduced into this country by Mr. Vermehr, and established over here as the Ransome-verMehr Machinery Co., this company controlling all patent rights on the Ransome machine for this country, the Continent of Europe, and the British colonies. Having established the machine here, it was obviously desirable that it should be entirely manufactured here, and consequently it was arranged that this work should be undertaken by Messrs. Ransome and Rapier, Ltd., of Ipswich. As is probably well known, the essential characteristic feature of the Ransome mixer is a cylindrical revolving drum fitted with roller paths and a gear ring, the paths on the drum being themselves in contact with, and supported by, four small rollers, and the gear ring caused to mesh with the driving pinion attached to the driving shaft. The interior of the mixing drum is provided with a series of scoops and baffles of special construction, which cause the aggregate, after entering the drum, to be repeatedly lifted, turned over, and passed from end to end of the drum. The action of these blades and baffles is such that for every complete revolution of the mixing drum the whole of the batch is turned over and intermingled once. As the normal speed of running of the mixing drum is 16 r.p.m., a batch of aggregate allowed to remain within the mixing drum for half a minute will have been turned over and intermingled at least eight times, and it is found in actual working that this is approximately the time necessary to produce a perfectly uniform and thoroughly mixed concrete.

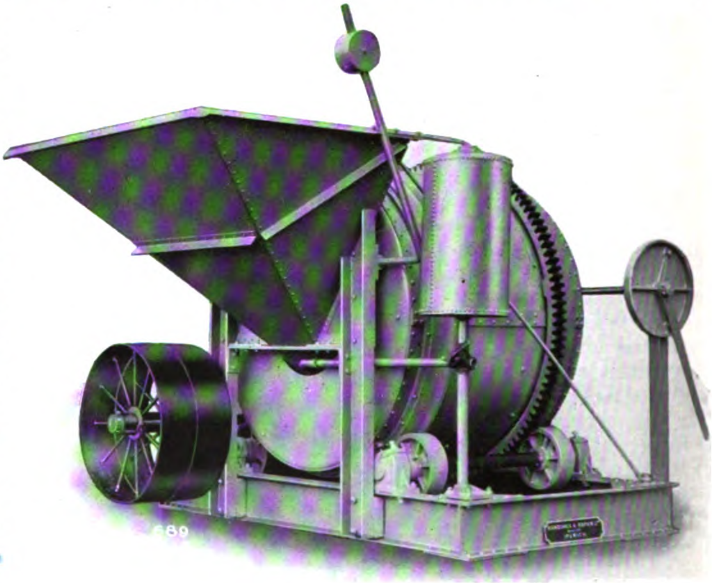


Fig. 1.

The machine is provided with suitable underframing, shafting and bearings to support and keep the drum in true alignment, whilst discharge from the drum is effected by means of a chute controlled by a hand lever, which, when required, is caused to enter the drum, catch the material as it is lifted by the wings and baffles, and pass it to the exterior of the drum on the front side of the mixer.

There are numerous methods of equipping the machine to meet all possible requirements of any class of concrete work, and furthermore the machine is made in seven different sizes with varying outputs. The smallest size—arranged for operating by power—gives an output of 25 cu. yd. per day of ten hours, whilst the largest size of all is capable of receiving for each batch 86 cu. ft. of material, and of yielding 1,000 cu. yd. of concrete per day of ten hours. This last-named size is only adopted for works involving very large quantities of concrete, such as dock and harbour construction and similar undertakings, and no less than nine of these large machines are at present in use in the construction of the Rosyth Naval Base at Inverkeithing.

Our illustration (*Fig.* 1) shows a standard Ransome mixer with fixed measuring hopper, whilst *Fig.* 2 shows the essential feature of the Ransome mixer—*viz.*, the drum.

In order to rapidly feed this mixing drum a measuring hopper is almost invariably supplied with the mixer, either as a fixed hopper or as an elevating hopper. The elevating hopper is arranged, by means of winding gear, to descend to ground level to receive a batch of aggregate, and it is then caused to ascend and discharge its contents direct to the mixing drum.

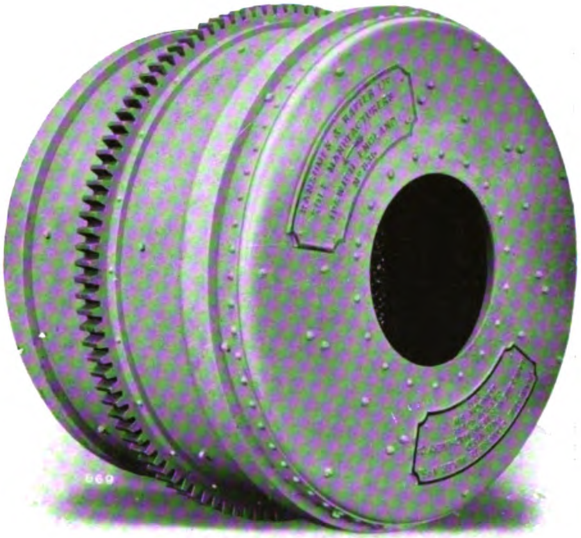


Fig. 2.

In conclusion it may be added that the Ransome mixers have been constructed in four distinct series :—

1. Machines fitted with fast and loose pulley for belt and drive;
2. Machines fitted with direct coupled steam engine and boiler;
3. Fitted with direct coupled electro motor; and
4. With direct coupled petrol engine.

Sutcliffe, Speakman & Co., Ltd.—The accompanying illustration shows a press which has been specially designed for the manufacture of building blocks, paving slabs, etc., from cement mixed with sand, gravel, slag, clinker, etc., and on which blocks may be produced at low cost.

The blocks are made as follows: The material, in a moist condition, is pressed into shape under a pressure of 250 tons each block, afterwards being hardened.

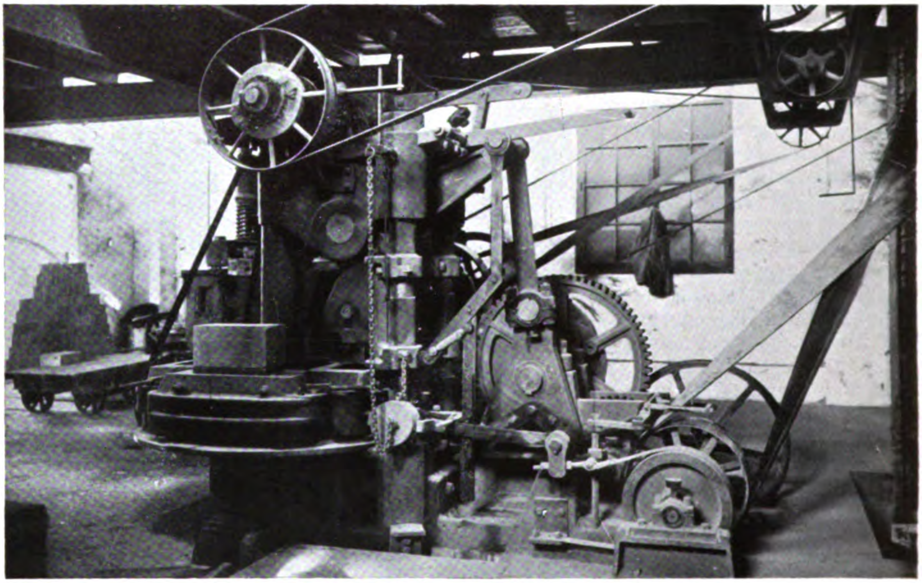
The size of the blocks, as also their shape, may be varied at will, it being possible to make them either stone-faced, plain, or worked. The largest block produced is 20 in. by 10 in. by 6 in., but half and three-quarter blocks, headers, etc., may be made with equal facility, and also hollow blocks 18 in. by 10 in. by 9 in.

The press illustrated consists of a revolving table, carrying the moulds, working in conjunction with a powerful bell crank lever, operated by a crank and double-geared driving arrangements.

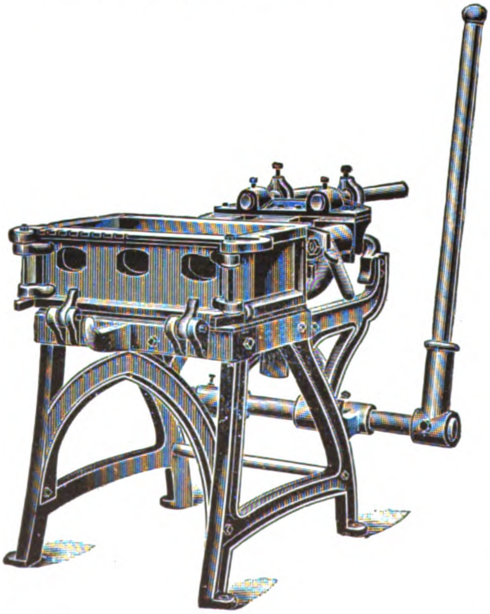
The table carries three moulds, leaving a blank space on the table, admitting of a free space for cleaning the top die at each revolution, if necessary. The table is rotated by a separate drive from that operating the press, and is started in motion by a clutch gear and lever. The pressing mechanism is operated by fast and loose pulleys and belt gear, set in and out of gear by an arrangement of levers, this gear being so arranged that it is impossible to set the press in motion unless the mould is exactly opposite the die.

The moulds are constructed with a loose front, which is locked when the block is pressed, and automatically loosened when the block is discharged, so that to eject the block little pressure is exerted by the machine, the block being quite loose in the mould and is pushed out ready for carrying away.

The distribution of the moulds is such that while one mould is being charged with material, the second is being pressed and a block is being discharged from the third. The output is about 150 blocks per hour.



Matthew Wylie & Co.—*Fig.* 1 shows *a Concrete Block-making Machine*, Model "A."—This machine will make either solid or hollow veneer blocks of a maximum length of 16 in.



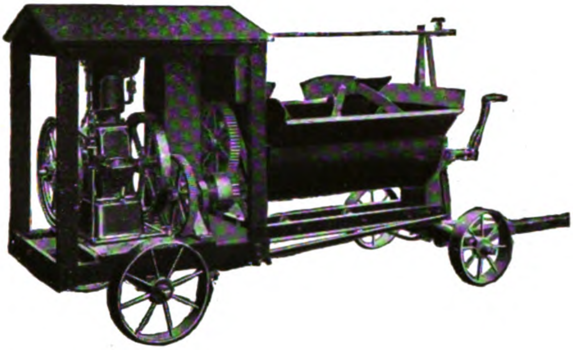
By using different attachments the blocks may be varied in width and thickness.

The base of the model is constructed so as to receive the various attachments belonging to this particular model. The width or thickness of any block to be made is governed by the depth of the mould box or attachment when fitted to the base. The blocks are made face down and are discharged from the mould box by the operator grasping the door handles and, after releasing, turning the block a quarter turn, thus bringing the face of the block to a vertical position with the block resting on the pallet or off-bearing plate ready to be carried away by the block carrier.

The firm also makes the "Ideal" block-making machine to turn out blocks 18 in. long by 9 in. by 9 in.

Fig. 2 shows the "Blystone" *Concrete Mixer*. One of the chief features of this mixer is the ease with which it can be cleaned. Further, the mixer is open and practically always ready for use. By being open the contents are constantly in full view of the operator, and he is thus able to control and rectify such mistakes as getting the material too wet or *vice versa*. These are, of course, important points in all concrete work.

By suspending a perforated pipe over the mixing drum a good watering device is obtained at very little expense, and the moulded mixer here shown is fitted with such a device. The output of the mixer is ¼ cu. yd. per batch in one minute.



The addresses of the foregoing firms are as follows :—
Mason Bros., Leicester.
Concrete Machinery Co., 290 and 290a, Vauxhall Road, Liverpool.
Murray, Workman and Co., Ltd., Craigton Works, Jura Street, Cardonald, Glasgow.
John Pickles & Son, Hebden Bridge.
The (U.K.) Winget Concrete Machine Co., Ltd., Star Buildings, Newcastle-on-Tyne.
T. L. Smith & Co., 13, Victoria Street, Westminster, S.W.
Ransome-verMehr Machinery Co., Ltd., Brunswick House, Westminster, S.W.
Sutcliffe, Speakman & Co., Ltd., Leigh, Lancashire.
Matthew Wylie & Co., 81-83, Portman Street, Kinning Park, Glasgow.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

The Practice of Construction in Concrete and Cement Mortar, Plain and Reinforced. (*Pratique de la Construction en Béton et Mortier de Ciment, Armés on non Armés.*) By Frederic W. Taylor and Sandford E. Thompson. Translated and adapted by M. Darras.

Paris, 1914, Dunod and Pinat. pp. 720 × xxi.
Price, frcs. 27.50.

This is a French adaptation of the two well-known works of Messrs. Taylor and Thompson, "Concrete, Plain and Reinforced" and "Concrete Costs," and reference may be made to the review of the latter work in CONCRETE for July, 1912, for an account of their general scope. The production of a French edition has necessarily involved a very great amount of labour, the whole of the tables, specimen calculations, etc., having to be converted from British to metric units. A complete conversion has not, however, been attempted; thus the prices of cement employed in the tables are American prices, converted into francs, but it is quite easy to use the tables with the current prices in France. The book in its present form is thus immediately available for Continental practice.

The system of "scientific management," associated principally with the name of Mr. F. W. Taylor, is attracting great attention from all those who are interested in the organisation of labour and in the improvement of industrial efficiency. Its application to mechanical engineering works, where elaborate systems of calculating piece-work rates are already familiar, is less difficult than its adaptation to such a process as concrete construction, where the details are less completely standardised, and haphazard methods are common. By providing such a treatise as this, in which the new methods are applied in the minutest detail, the authors have rendered a most valuable service. From the excavation of sand and gravel in the pit or the blasting of hard rock from the quarry as aggregate, down through the processes of mixing, transport and setting in place of the concrete to the finishing of a reinforced construction, every operation is considered in turn with respect to the time occupied and the cost of labour. It yet remains to be seen whether constructional engineering firms will adopt the system, with the efficient skilled supervision which it presupposes. Should the experiment be made in Europe—and the present volume makes the trial possible—the results should prove of the highest possible interest, and the success of the method in its application to reinforced concrete construction would be a striking confirmation of the value of Mr. Taylor's system. From every point of view the authors and adapter are to be congratulated on having produced a treatise of remarkable originality, which calls for the attention of every constructional engineer.

Tests of Bond between Concrete and Steel. By Duff A. Abrams. Bulletin No. 71.

Published by the University of Illinois, Urbana. European Agents: Chapman and Hall, Ltd., London. Price, One Dollar.

Contents. — Introduction — Materials, Test Pieces, and Methods of Testing —Experimental Data and Discussion — Pull-out Tests — Reinforced Concrete Beam Tests—Summary.

This is an excellent volume dealing with a very important question in reinforced concrete construction, and much discussion has taken place at various times as to the bond resistance with different conditions and shapes of bars. The tests which are described cover many descriptions of bars and the effect of variations in the dimensions of pull-out specimens, the effect of shape and condition of surface, condition of storage, deformed bars, effect of age and mixing, and of anchoring the ends. Miscellaneous tests were also carried out, together with various tests on reinforced concrete beams. Many tables and diagrams are given throughout the bulletin, and a very good summary enables the reader to realise the salient points and appreciate the effect of the different conditions imposed for each test. Some of the points in the summary are well worthy of notice on account of the light which they throw on matters about which there does not seem to be universal agreement.

It was found that adhesive resistance is much the more important element of bond resistance, and the maximum bond resistance was not materially different for bars of different diameters. Rusted bars gave bond resistance about 15 per cent. higher than similar bars with ordinary mill surface, and square bars gave values of unit stress about 75 per cent. of those obtained with plain round bars. With regard to deformed bars it was found that the adhesive resistance must be destroyed and the usual sliding resistance largely overcome, and the concrete ahead of the projections must undergo an appreciable compressive deformation before the projections on a deformed bar become effective in taking bond stress. Also in a deformed bar of good design the projections should present bearing faces as nearly as possible at right angles to the axis of the bar. The load-slip relation for bars anchored by means of hooks and bends was not determined. It is considered that the high resistance which was given in these tests was probably a result of the bearing stresses developed in the concrete ahead of the bends.

The notes dealing with the tests on the beams contain many items of interest, and we are pleased to observe that additional tests are planned, with a view of studying the bond stress in conjunction with the variations of the tensile stress in the reinforcing bar, and when the report of these is published it should prove very valuable, if containing anything like the information given in the present volume.

The Architects' Standard Diary.

Published by the Standard Catalogue Publishing Co., Ltd., 26 Hart St., London, W.C., and issued under the auspices of the Architects' Technical Association. Price 4/6.

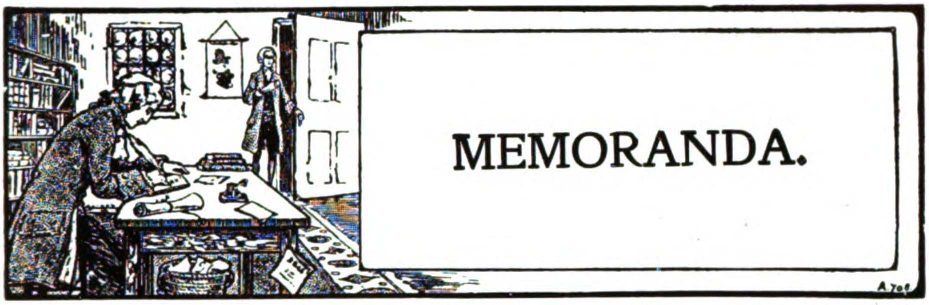
In connection with the new edition (1914-1917) of the Architects' Standard Catalogues, a Standard Diary has been issued, which contains much useful matter, apart from the general subject index to the above-named catalogues. Before referring further to the Diary we would mention the catalogues in passing, which comprise some five large volumes and contain information upon every trade directly or indirectly connected with architectural work.

The Diary here under review contains many general notes of value to architects in the erection of such buildings as artisans' dwellings, cinemas, cold storages, concert halls, churches, etc.

There are special sections devoted to reinforced concrete, electricity, heating, and sewage disposal.

Very useful is the chapter "Architects' Price Book," compiled by Mr. B. E. Laine-Pearson.

Besides these matters the Diary contains much other useful information, and should prove very handy to the special profession for which it is intended.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The British Fire Prevention Committee is still short of fire surveyors (architects, surveyors and insurance officers) for occasional fire survey in the South of England, home counties and east coast, and will be glad to receive applications addressed to the Special Fire Service Force, 8, Waterloo Place, London, S.W.

Manchester School of Architects.—The Kalendar for the session 1914-15 is now obtainable. It is also announced that a special course of lectures is in progress on Specifications and the Aesthetic Properties of Building Materials. These lectures are held on Thursday evenings at the Manchester School of Technology. The fee for the course is 10s. 6d.

The lectures will deal with the use and properties of building materials, with special respect to the part they play in architectural design. They will also deal with the ground covered by the papers on specifications and materials in the final and intermediate examinations of the R.I.B.A., and with the conduct and supervision of building works.

The lectures will be illustrated by lantern slides, photographs, and working drawings, and numerous specimens of building materials, with special reference to those obtainable in the locality of Manchester.

For copies of the above Kalendar and full particulars of the lectures apply to the Secretary, Manchester Society of Architects, 36, Spring Gardens, Manchester.

Reinforced Concrete Bridge, Lingfield.—A new reinforced concrete bridge was recently built by the Godstone Rural District Council, of which the *Building News* gives the following details:—The bridge has a span of 30 ft., and a clearway between parapets of 18 ft.; abutments are in solid concrete, about 11 ft. deep, and the superstructure consists of specially gauged concrete with steel-bar reinforcement. The new road is now complete, and the whole surface from Haxted Mill, via Cottage Lane, to Moor Lane, has been made up and tar-washed. The cost of the works has been £3,860. Mr. Geo. E. Crowther, M.I.M.C.E., surveyor to the Godstone Rural District Council, was the engineer to the scheme; Messrs. Robinson and Co., of Westminster, were the contractors; and the Indented Bar and Concrete Engineering Company, of Westminster, supplied the steel reinforcement.

Concrete Blocks for Dwellings.—It has been decided by the Admiralty to erect 200 houses at Crombie, near Dunfermline. Concrete blocks are to be used for these dwellings.

The Treatment of Granolithic Floors.—In the design of a concrete structure an important question is whether a granolithic floor should be put on as an integral part of the construction or as a second part of the operation. If the latter, its thickness has to be seriously considered. For economy's sake, both in materials and labour, it is cheaper to put on the finish with the construction, states Leonard C. Wason, President of the Aberthaw Construction Co., Boston, in a paper before the Boston Society of Civil Engineers.

Under these conditions, however, it is frequently impossible to keep the men off the floor long enough for it to harden up sufficiently to keep it from being marred. If this is a serious objection the finish must be put on as a second operation. In this case it does not bond sufficiently well with the floor so that the two may be considered as a unit; hence the construction should be thick enough to carry the load without any assistance from the finish.

If the finish be 1 in. thick it will work loose in spots; whereas, if 2 in. thick it is pretty safe to guarantee it to be solid and satisfactory. This thickness, however, adds to the dead weight and to the expense. It is necessary to settle these points before construction begins in order to get the minimum of cost and the maximum of efficiency, as the amount of forms bought and the conduct of work are influenced by it.

Reinforced Concrete Trunk Sewer.—There is now under construction in Victoria, B.C., a reinforced concrete trunk sewer about two miles long, which is to drain about 425 acres in a rapidly growing residential section of the city, as well as 1,000 acres in Esquimalt and 800 acres in Saanich. The sewer starts with a 27-in. diameter and increases to a 36-in. pipe at the outfall near Macaulay Point, where tidal currents were deemed favourable for disposal without nuisance. For several hundred feet near the lower end of the sewer steel pipes were used, and were continued to a discharge below water level. The remainder of the line, however, consists of reinforced concrete pipe, cast in 5-ft. lengths. In laying the pipe there are required about 3,100 ft. of trench, largely in rock, and 7,250 ft. of tunnel, practically all in solid rock. The tunnel work is comprised in three separate bores ranging up to 65 ft. in depth below the natural surface, and known as tunnels X, Y, and Z. The first of these tunnels is now being driven with the aid of two shafts sunk from the surface above. This tunnel is 7 ft. high by 5 ft. wide, and is being advanced at the rate of about 5 ft. per day. About 135 men are now engaged on the work.—*Engineer.*

New Concrete and Steel Building in the City.—The new premises now in course of erection for Messrs. Spicer Bros. in New Bridge Street are being constructed entirely in steel and concrete. The structure will rest on concrete piles, this being the first occasion on which concrete piles have been used in the City.

Concrete Roads.—In a recent issue we published a short description of a concrete road in Chester, and we now learn from our contemporary, the *Building News*, that experimental sections of concrete roads are to be laid down on the Strood road, near Gravesend. Four isolated lengths of 75 yards of the road will be taken up and relaid with concrete. The British Portland Cement Co. will supply the material free of cost, and of the remaining expenditure, estimated at £550, one-third will be borne by the Kent County Council, and another third by the Road Board, the remainder being locally provided.

Annals of the Mexican Department of Public Works.—We have received No. 7 of the second series of Annals of the Mexican Department of Public Works (*Anales de la Secretaria de Comunicaciones y Obras Publicas*), dated 1914. This part contains an account of the design of a lighthouse in reinforced concrete for the port of Coatzacoalcos. The article is remarkable for the very full drawings which it contains, covering no less than 26 folding plates. The light is 33·8 metres above the level of the rock, and the entire structure is in reinforced concrete, comprising a tower of seven stories below the lantern and a building of two stories. The design is by José Certuche, and the article, which gives full details of the computations, is by M. Caldéron y Barrada. The same number contains the description of a cantilever bridge recently erected over the Río Chico.

A Wash for Concrete.—A wash for concrete consisting of a dilute solution of hydrochloric acid, one part of commercial 30 per cent. acid to five parts of water, has been found effective in cleaning the stains from the lock walls of the Panama Canal.

Paint Protection for Portland Cement Surfaces.— Mr. H. A. Gardner, of Washington, D.C., has recently published a Paper in which he gives an account of a series of tests instituted by him with a view to determining the durability of various types of paint on Portland cement surfaces exposed to weather. The panels for the tests were prepared by constructing a long board wall, to which was fastened expanded metal. A mixture of one part of Portland cement and two parts of clean Potomac River sand was made and applied to the expanded metal, forming a cement wall 3 in. in depth. The wall was divided into thirty-five sections or panels, each 30 in. wide and 40 in. high. Three coats of paint were applied to each panel. In order to make the test more severe, nearly all of the paints were applied in white. (Tinted paints are known to be much more durable than white paints.) A strip of chrome green, 6 in. wide, was placed over the top of the third coat of paint, in order to determine whether or not the lime which might be present on the surface of the cement would have any effect upon the paint coatings. Fading of the green to a yellow would indicate such action. A priming coat of 25 per cent. zinc sulphate solution was applied to the panels to neutralise any free lime; but this is held to be unnecessary if the surface is dry when painted and if it will not be exposed to the weather.

The tests showed that the amount of free lime in fairly dry cement surfaces does not adversely affect high-grade oil paints. The tests also showed that zinc sulphate may be used with excellent results as a primer to neutralise free lime in damp cement surfaces which are to be painted. Opaque white pigments, such as basic-sulphate white-lead, basic carbonate white-lead, zinc oxide, and lithopone, were present in the paints which gave the best results. In some of these paints there was present a percentage of inert pigments, such as barytes, asbestine, whiting, china clay, gypsum, and silica. The scaling of varnish paints, which developed in several tests, apparently showed that resinous paints are not well suited for cement surfaces.

The oil paint is not attacked by the dry cement, and holds both texture and colour. Equally satisfactory results were obtained with boiled linseed oil, mixtures of raw and boiled oil, and mixtures with Chinese wood oil. Such simple paint coatings were also found to be excellent for concrete floors, being durable, wear-resisting, and dust-preventive. The results of these tests are quite in line with the results obtained by Ware and Schott in a series of paint-exposure tests made upon exterior concrete surfaces. They also agree with previous long-time exposure tests made by the author.

As a result, therefore, it can be stated that excellent results may be obtained by treating cement walls or floors with paints made with raw and heat-treated linseed and Chinese wood oil, containing durable, wear-resisting pigments. When the cement surface is freshly laid and damp such paints may be safely applied, after treating the cement with a zinc sulphate primer. The general results of the tests at the end of a two-year period, together with an outline of the composition of the paints tested, is given as follows:

Class No. 1.—Single-segment paints made with white-lead or zinc oxide ground in pure linseed oil. (These paints are in very good condition throughout.)

Class No. 2.—Combination-pigment paints made of mixtures of white-lead, zinc oxide, or similar pigments ground in pure linseed oil. (These paints are in generally excellent condition.)

Class No. 3.—Combination-pigment paints ground with mixtures of raw and heavy-bodied linseed oil or with treated Chinese wood oil The viscosity of these oils requires the use of considerable turpentine or other thinner in the manufacture of such paints, in order to make them of the right viscosity for application. Semi-flat surfaces are therefore produced during the drying.

Class No. 4.—Single and combination pigments ground in oil varnishes containing acid resins. (These paints are checking and scaling in many spots. Such varnish paints are apparently not suited to exterior exposure.)

Class No. 5.—Paints containing resins dissolved in volatile spirits (spirit varnishes) with or without pigments. (These paints are not giving very satisfactory service, the clear varnishes having entirely decayed in some cases. Those to which pigment has been added are in somewhat better condition.)

Class No. 6.—Paints made with single and combination-pigments ground in a water medium containing glue or casein as a binder. (These paints are chalking rapidly and are not moisture-proofing the cement. The pigment binder has been destroyed by the weather.

Framed Concrete Engine Bed. — A framed reinforced concrete engine-bed, embodying several novel features, is now in use at Rockford, Ill. The frame is 11 ft. 6 in. wide at the base and 6 ft. 10 in. at the floor line. Monolithic with the frame are two reinforced concrete engine-beds 5 ft. 4 in. long, 24 in. wide, and 20 in. high. The rods holding the engine to the bed were not bedded in the concrete; iron pipes were cast in the concrete, leaving openings through the bed proper, through which the bolts were passed after the engine was placed. Heavy washers were placed on the lower end to make a better bearing for the lower nuts. Both ends of the bolts were threaded. A platform 6 in. thick was placed 6 ft. above the basement floor, which served the double purpose of providing a convenient place on which to work while placing the bolts and acting as a stiffener to the columns and preventing torsion due to the action of the double 50 h.p. engine. Although the frame carries a double 50 h.p. engine, scarcely any perceptible vibration has been noted under a full load.

The structure was designed for the Rockford Paper Mill, Ill., by Chas. C. Stowell, Consulting Engineer.—*Engineering Record.*

A New Interlocking Concrete Block Pipe.—In *Concrete-Cement Age* an account is given of a new type of interlocking concrete block pipe which has recently been used in sewer work in Houston, U.S.A.

The pipe is built up in rings, the number of blocks to each ring depending upon the diameter of the pipe. For 36-in. and 48-in. pipe there are four blocks to each ring. These blocks or segments have grooves formed in the two sides and at both ends, and a locking rod moulded in the centre of each block protruding therefrom and serving to lock the transverse circular reinforcing rod into the groove shaped to receive it. The blocks themselves are reinforced with two small rods close to the inner surface and following the curvature.

The blocks, breaking joints longitudinally with the locking rods embedded in these joints, and hooked around each ring, make an interlocking construction, well bonded together. The fact that these joints are staggered is of special importance for large sewers and tunnels where it is necessary to force the shield ahead by jacking against the completed tunnel lining. The blocks are joined together with Portland cement mortar, all joints being well filled and pointed up.

It is claimed that the principal value of this new type of concrete block lies in the fact that it requires the least amount of excavation possible.

Short tunnels, from 50 ft. to 60 ft. long, have been built in 30-in. to 36-in. block pipe without disturbing the pavement and without the use of timbering or centering of any kind.

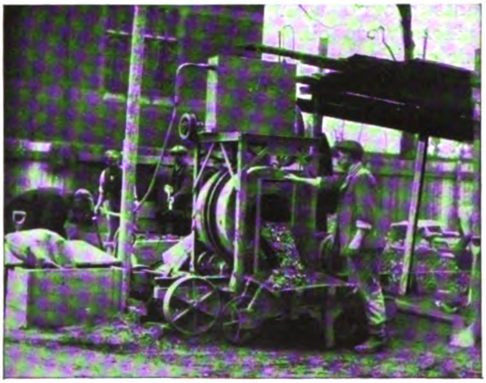
CATALOGUES RECEIVED.

Mr. Henry Walker, M.E., F.C.S., has just issued a folder giving particulars of his machinery made in Great Britain for use in the cement, lime and chemical trades.

Some excellent illustrations are shown of the "Maxecon" Mill, the new type "Kent" Mill, the improved "Krom" Crusher, the "Perfectecon" Screen Separator and the new "Perfectecon" Air Separator.

Our readers, if they have not already received this circular, should write to the office at 31-33, High Holborn, London, W.C., for a copy, which will be sent to them by return.

The firm specialise in crushing, grinding, separating, elevating and conveying machinery for any hard and refractory materials.



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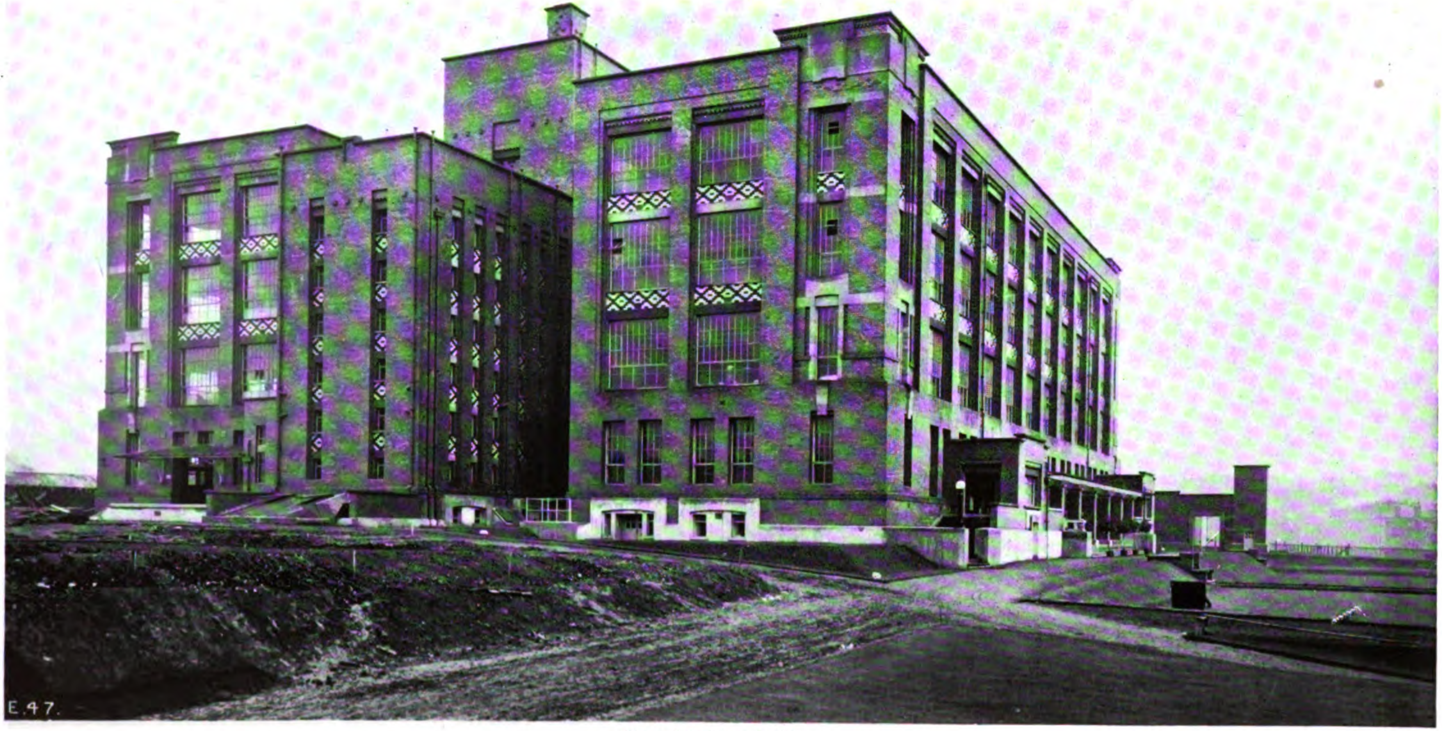


View of finished Building.
The Wallace-Scott Tailoring Institute, Glasgow.
(For description see page 711.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume IX., No. 12. LONDON, DECEMBER, 1914.

EDITORIAL NOTES.

THE LATE MR. ARMAND CONSIDÈRE.

IT is with great regret that we have to record the death of Mr. Armand Considère.

His work in the engineering world was of the greatest importance, and he has rendered valuable services in the study and application of reinforced concrete.

Mr. Armand Considère was born on June 8th, 1841, and entered the Paris Polytechnic School in 1860, and in 1862 he passed on to the Ponts et Chaussées School. In the period 1865 to 1904 he successively held the appointment of Engineer, Engineer-in-Chief, and finally Inspector-General of the Ponts et Chaussées.

During his long administrative career, covering some 40 years, Mr. Considère carried out a large amount of work on road, railway, harbour and lighthouse construction.

In spite of his arduous work, he was able to make numerous studies (*études*) and to issue a large number of publications, notably among them being the part played in the economics of the nation by local railway systems and on the usefulness of such lines; a report on earth pressures; the properties and the use of steel; shocks on the permanent way; rivetted work, etc.

As far back as 1892 Mr. Considère drew attention, in a report presented to the Commission for the Testing of Materials, to the fact that, a steel having a high tensile strength, able to bear a high percentage of elongation without fracture and to withstand with complete success all the required tensile tests, might nevertheless be a very fragile steel, and a steel the use of which might be surrounded with real danger.

At the same time he defined and proposed the test for fragility, the importance of which has since been admitted all over the world. In the same year, 1892, the Academy of Science appointed Mr. Considère a corresponding member in recognition of the services he had rendered to civil engineering.

It was in 1899 that he first turned his attention to reinforced concrete. At that time he published his treatise entitled "The Influence of Metallic Armatures on the Properties of Mortar and Concrete," in which were given for the first time rational formulæ for the calculation of reinforced concrete.

In 1901 he invented the spiral system of reinforced concrete, with which his name will always be associated, and since its introduction in England in 1908 it has been largely used in this country.

In 1901 he published his treatise entitled "Resistance to Compression of Ordinary Reinforced Concrete compared with that of Spiral Reinforced Concrete." A further treatise on the subject appeared in 1907 entitled "Spiral Reinforced Concrete and its Applications."

He further designed and patented a number of other processes for civil engineering construction, of which we would mention three: (*a*) conical foundations; (*b*) temporary joints of spiral reinforced concrete for arched bridges; (*c*) the use of friction slabs to withstand abutment and earth pressure.

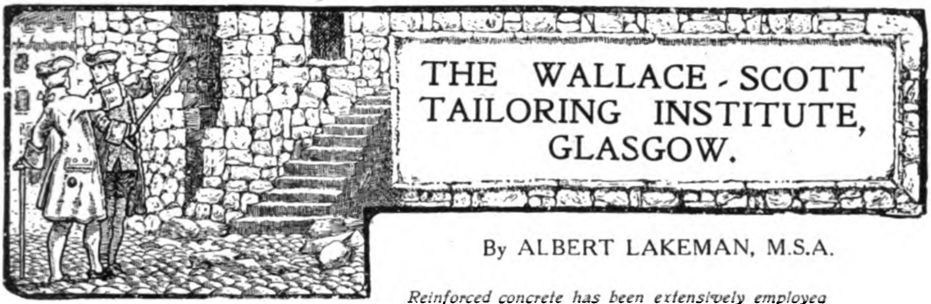
Mr. Considère was appointed Chairman of the Commission on Reinforced Concrete, which drew up the regulations published in 1906 by the French Ministry of Public Works. He took a very large share in the experiments and work undertaken by this Commission.

In acknowledgment of his work in the interest of science, the International Association for the Testing of Materials appointed Mr. Considère President of the International Commission on Reinforced Concrete in 1907. His age and his numerous other duties, however, did not enable him long to hold this position of honour.

With the death of Mr. Considère, the world probably loses a pioneer scientist in reinforced concrete, whose reputation, both in scientific research and previously as an engineer of official eminence, was international.

There is no one who has quite stood on the same plane as the late Mr. Considère as a professional man interested in the new material, and the bare fact that he also applied his inventive genius to a particular system in which he was industrially interested, in no way dimmed his great and world-wide reputation as a scientific engineer of the first order.

Mr. Armand Considère.



THE WALLACE-SCOTT TAILORING INSTITUTE, GLASGOW.

By ALBERT LAKEMAN, M.S.A.

Reinforced concrete has been extensively employed in the new Wallace-Scott Tailoring Institute which has recently been erected at Cathcart, Glasgow. - ED.

It is very fitting that a modern scientific material should have been adopted in the construction of these buildings, which are essentially modern in planning and equipment.

The architects for the buildings are Messrs. John Burnet and Son, of Glasgow, and the comfort and convenience of the workers have been considered to such an extent that the keynote to the design is provided in the expression "contented workers." The promoters have realised that the employees will produce the best work when they are comfortable and well cared for, and the accommodation provided certainly leaves nothing to be desired. It is a large undertaking, and deserves success, as being based on the right principles, and the employees' comfort has not only been considered during business hours, but also at other times in the provision of extensive recreation grounds.

The site is an excellent one, it being on rising ground adjacent to the River Cart, which forms a boundary on the lower side and which necessitated the building of a bridge spanning this river for access to the grounds.

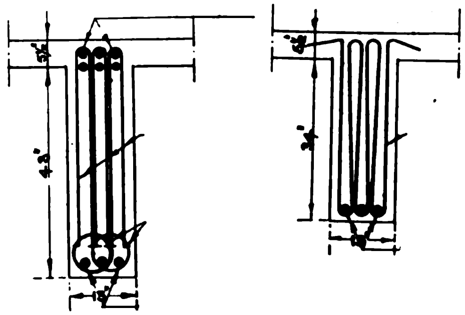


Fig. 1. Beam Details.
The Wallace-Scott Tailoring Institute, Glasgow.

A general idea of the arrangement of the buildings can be gathered from the plan illustrated in *Fig.* 2, and it will be seen that it consists of a front main block having a frontage of over 160 ft., with two side wings extending back for a distance of 200 ft., and between these wings the lavatories are arranged with the staircases and connecting passages. Apart from a small basement provided for the heating chamber, etc., there are four floors in the main structure, and the cubical capacity of the building is such that it exceeds the limit allowed under the Building Act, and a special application had therefore to be made to the City Council to avoid the necessity of putting interior party walls, which would have been very detrimental to the working and supervision in the building and would have added considerably to the cost. This application

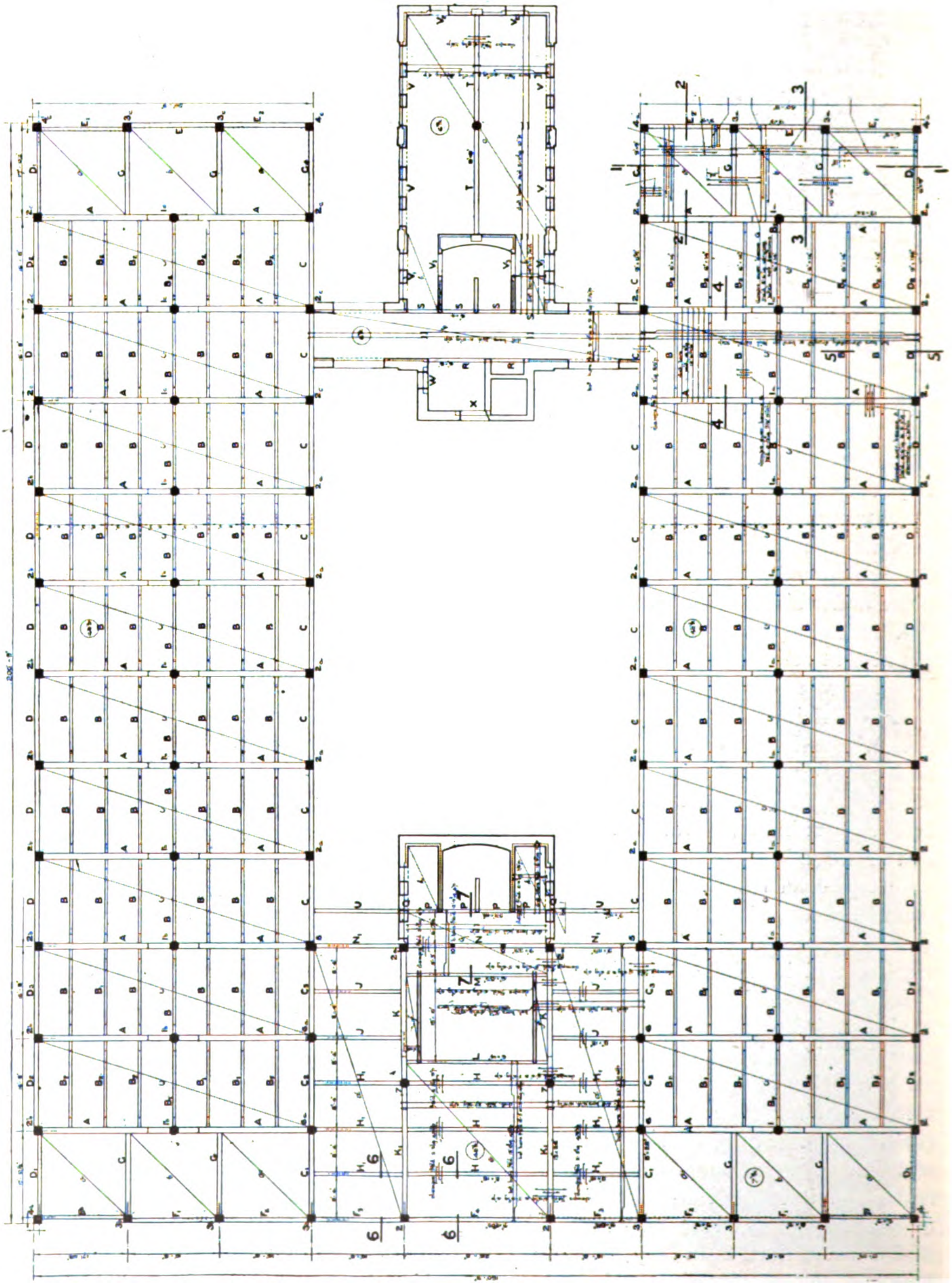


Fig. 2. General Plan of First Floor.
The Wallace-Scott Tailoring Institute, Glasgow.

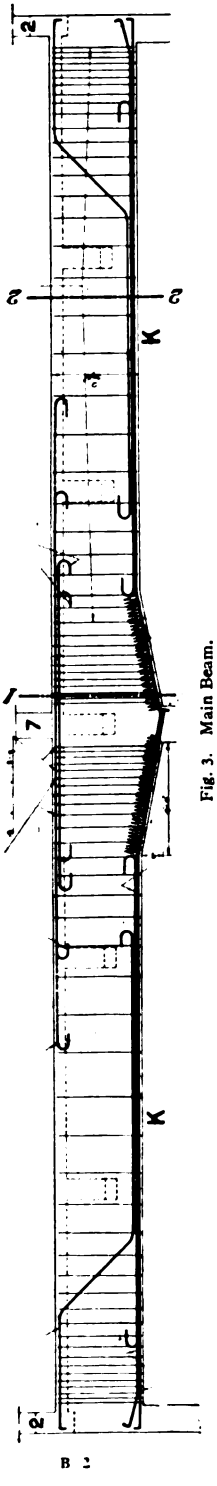


Fig. 3. Main Beam.

The Wallace-Scott Tailoring Institute, Glasgow.

was granted, and there is no doubt that it was influenced by the fact that the whole of the construction is practically fire-resisting and all the staircases are planned to come outside the main walls of the building; thus the risk in case of fire is reduced to a minimum.

The whole of the construction is executed on the "Considère" system of reinforced concrete from detail drawings prepared by the Considère Construction Co., of Victoria Street, Westminster, and it provides one of the best examples in existence of the speed with which a building can be erected in this material.

There has been much discussion of recent years as to the relative values of reinforced concrete and steel when speed of erection is of primary importance, and many engineers are so conservative that they will not admit the fair value of the former material or allow that it is capable of being built up as quickly as steel alone. The building provides an actual example of competition between the two materials, where the period required by the contractors was found to be the same. The minimum time required for ordinary steel-framed construction was seven months, and the whole of the reinforced concrete work was executed in seven months under a penalty, and when the size of the building is considered this is a remarkable achievement and indicates what can be accomplished when the work is planned, detailed, and organised in a systematic and competent manner. The time allowed for the whole of the work dated from the time when the general drawings were approved, and after this all the detail drawings had to be prepared and materials delivered to the site before the actual building work could be commenced. The use of reinforced concrete, furthermore, was found to be considerably cheaper than steel, and thus the total cost of the building was kept down to the minimum, while the construction gained rather than lost in efficiency.

The total height of the building from the ground-floor level to the roof is about 62 ft., each of the floors having a clear height of about 15 ft., and each of the side wings previously mentioned as being 200 ft. long have a width of 50 ft. The spacing of the beams and columns can be seen in the plan above-mentioned as *Fig.* 2, and it will be noticed that there is only one internal row of columns in the side wings, thus leaving fine, unobstructed floors for working purposes. The greater portion of the central block is devoted to the offices and the side wings to the workrooms, but one floor of one wing is utilised as a dining hall, with well-equipped kitchens and services. Intermediate rows of columns were introduced to carry the beams at the ground-floor level, as there was no question of obstruction, and this allowed the sizes of the beams to be reduced. The spacing of the columns in the central block was influenced by the planning of the internal divisions, and the same lines could not be followed by the beams right across the width of this portion.

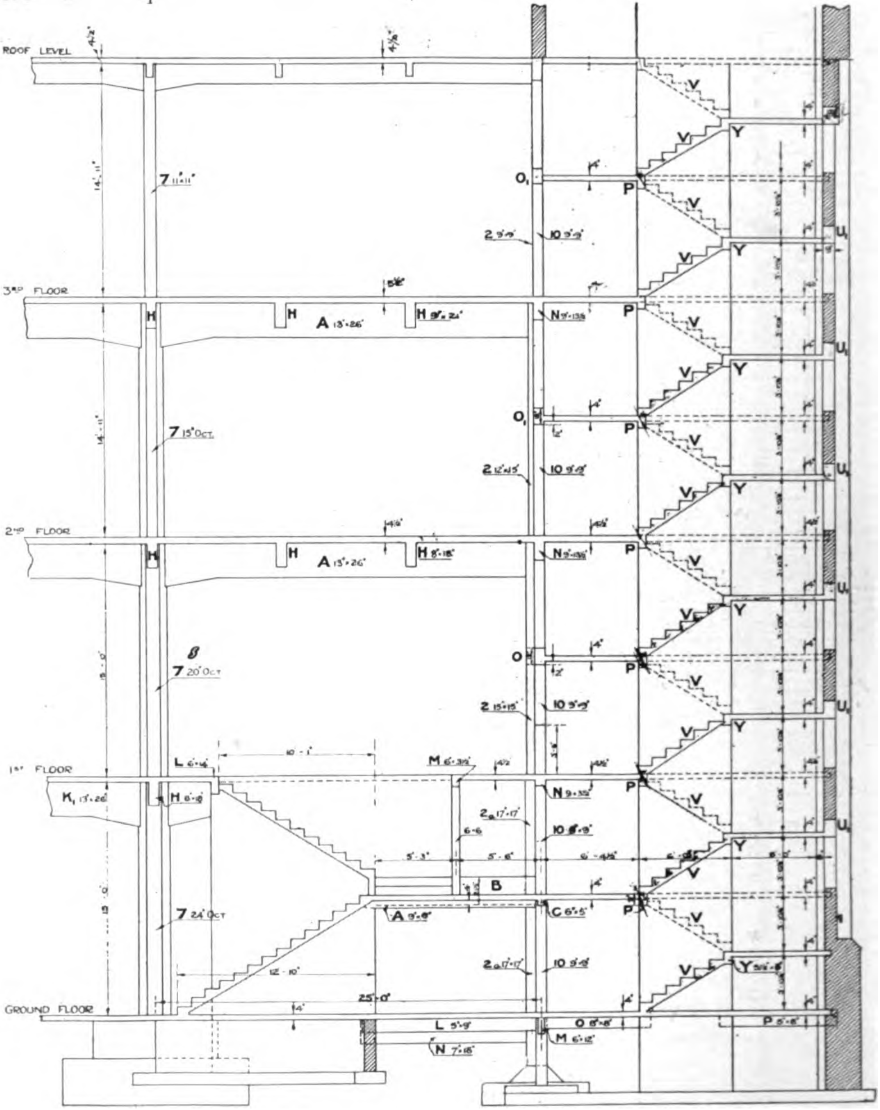


Fig. 4. Part Section Showing Stairs.
THE WALLACE-SCOTT TAILORING INSTITUTE, GLASGOW.

A typical detail of a column base is illustrated in *Fig.* 6, and it will be seen that this consists of a slab of concrete 8 ft. square and 2 ft. thick, with rein-

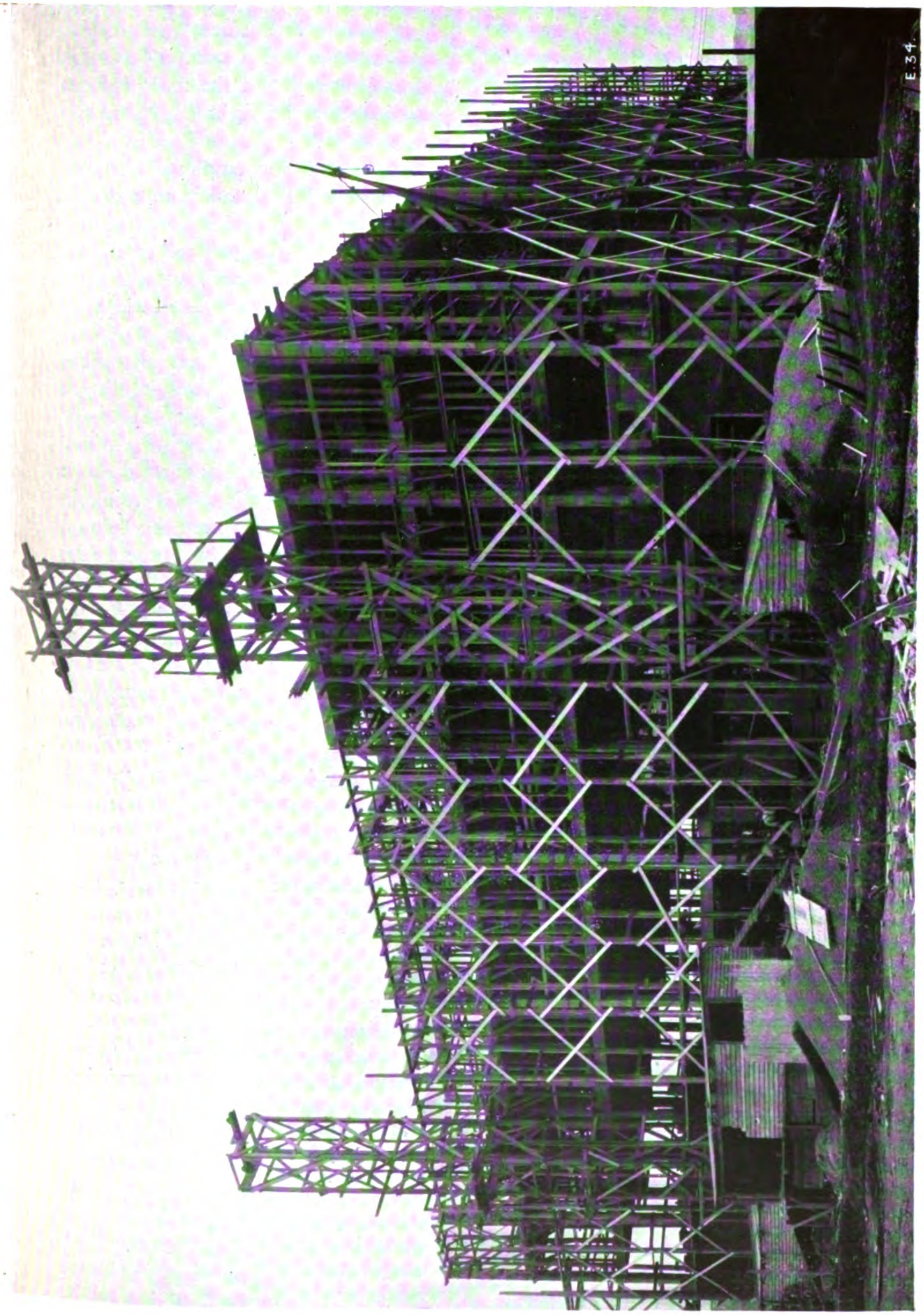


Fig 5. General View of Work in Progress.
THE WALLACE-SCOTT TAILORING INSTITUTE, GLASGOW.

forcement composed of a lattice of steel rods in the lower surface, with several stirrups to anchor same to the mass of concrete above, and a smaller lattice in the upper surface. The ends of all the rods are hooked and the main column rods are carried well down into the base and bent out at right angles to the length.

There are seven different sizes and types of foundation employed, according to the loads on the columns, and the detail here illustrated is that of the largest which occurs. A typical column detail is illustrated in *Fig.* 7, this showing one of the largest which occurs in the interior of the building. It is situated in the centre of the front block, where some large span beams have to be carried. They are octagonal on plan with a width of 24 in. between two opposite faces, and the reinforcement consists of twelve vertical rods, eight of which are arranged in circular form near the outer edge of the column, and the remaining four are situated in the core, as shown in the detail. These last-mentioned bars are tied with links at intervals, and the bars, arranged in circular form, are wound by a spiral, which increases the strength of the column considerably. This spiral is carried down into the column foundation for a distance of 6 in. The method of turning in and lapping of the bars is also shown at the first-floor level, where the column is reduced to a 20-in. octagon reinforced with eight bars only, these being arranged in the circular form with spiral binding, and at the second-floor level the column is again reduced to a 15-in. octagon with the same type of reinforcement. For the top floor a square column with a length of side of 11 in. is used, and here there are four bars only, arranged at the corners with ties at 6-in. pitch. In the side wings of the building the columns are arranged in three rows across the width, two of which are situated in the outer walls and only one row in the interior, and as the width of each wing is about 50 ft. the columns are 25 ft. apart in this direction. The longitudinal spacing is arranged to give twelve bays in the length, and the columns are about 16 ft. 6 in. centres. The wall columns are 17 in. square on the ground floor, with eight lines of vertical reinforcement tied with links around the outer edge and across the core, and these columns are reduced to 15 in. square on the first floor, with eight rods, 15 in. by 12 in. on the second floor with six rods and 9 in. square with four rods on the third floor. The central row of columns which occurs between these wall columns is composed of 22-in. octagonal columns on the ground floor with twelve vertical rods arranged in a similar manner to that explained for the previously mentioned octagonal section, but from the ground-floor level down to the foundation, which is a varying dimension, the column is increased to 26 in. square, all the upper rods being continued down and four additional rods being placed in the corners of the concrete which comes outside the line of the octagon above. The spiral binding is continued down into the base, and ties are provided around the four additional rods. These columns are reduced to a 20-in. octagon on the first floor with eight rods, to a 15-in. octagon on the second floor with a similar number of rods, in both cases arranged in circular form with spiral binding, and to 9 in. square on the third floor with four vertical rods and ordinary ties. Several other large columns occur, some of which are octagonal and others square or rectangular, while those at the angles of the building are shaped to suit their positions. In the small basement that is formed there is a column 28 in. square reinforced with eight rods, this supporting a reinforced beam 30 in. by 28 in., which in turn carries the wall above. This beam is reinforced with eight rods in the upper surface and four in the lower surface when passing over the column, although the clear span is only about 11 ft., as the load is considerable.

On the whole of the upper floors the main beams in the side wings run across the width and take a bearing on the wall columns and interior central row of columns, being continuous over the latter and supported only at the wall ends, and these beams therefore have a span of about 25 ft., and each carries the ends of six secondary beams, which are spaced at about 6 ft. centres. These main beams have a total depth at the centre of 30½ in. and a width of 13 in., with nine rods as reinforcement, all placed in the lower surface. Haunches 4 ft. long are introduced adjacent to the central column to increase the depth to a maximum of 38½ in., and here the reinforcement consists of six bars in the upper surface and three in the lower. In addition to this two spirals are introduced in the haunches to assist in the resistance to compression, and this is an excellent method to adopt. All the bars are hooked at the ends and stirrups are provided throughout the length. The secondary beams carried by these main members are 6 in. wide, with a depth at the centre of 18½ in., increased to 22½ in. at the ends by haunches 1 ft. 9 in. long. Four bars are provided in the tensional area at the centre and the ends, and in addition there are two rods in the compressional area at the ends. In these beams also the ends of the bars are hooked and stirrups are provided throughout the length to anchor the main bars to the mass of concrete and provide resistance to shear. It will be seen, on reference to the plan, that no secondary beams were introduced in certain of the bays, and, in consequence, the slabs were here made 7 in. thick, reinforced with bars at varying pitch in both directions on the lower surface, and with additional bars to provide continuity over the supports. The other slabs were 4½ in. thick, reinforced with bars at 5½-in. pitch across the short span, and with distribution bars across the longer span. Short bars were also provided in the upper surface when passing over the secondary beams.

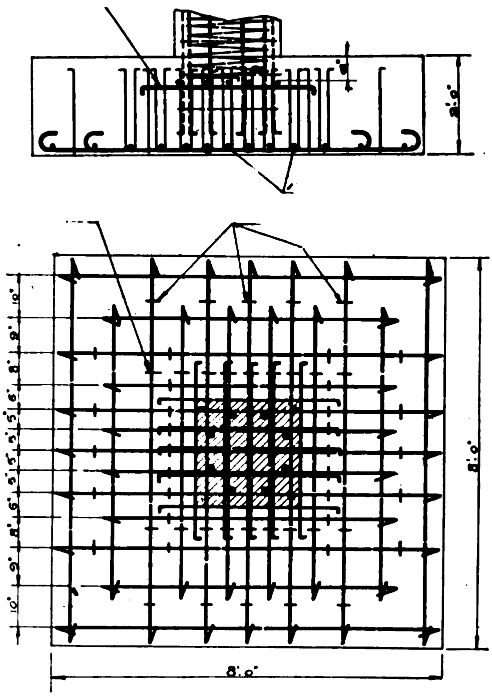


Fig. 6. Details of Bases to Columns.
The Wallace-Scott Tailoring Institute, Glasgow.

The beam illustrated in *Figs.* 1 and 3 shows the type of large main floor beam which occurs in the central block. This beam has a total depth at the centre of 39½ in., with a width of 13 in., and this is increased to 48½ in. at the point where passing over the intermediate column by haunches 4 ft. long. Spiral reinforcement is also used in these haunches, and, as shown in the sections, there are three bars in the lower surface at the centre and the ends, and also six bars in the upper surface at the ends only. In several beams where the loads were comparatively and the depth restricted spirals were introduced to assist in the compressional resistance.

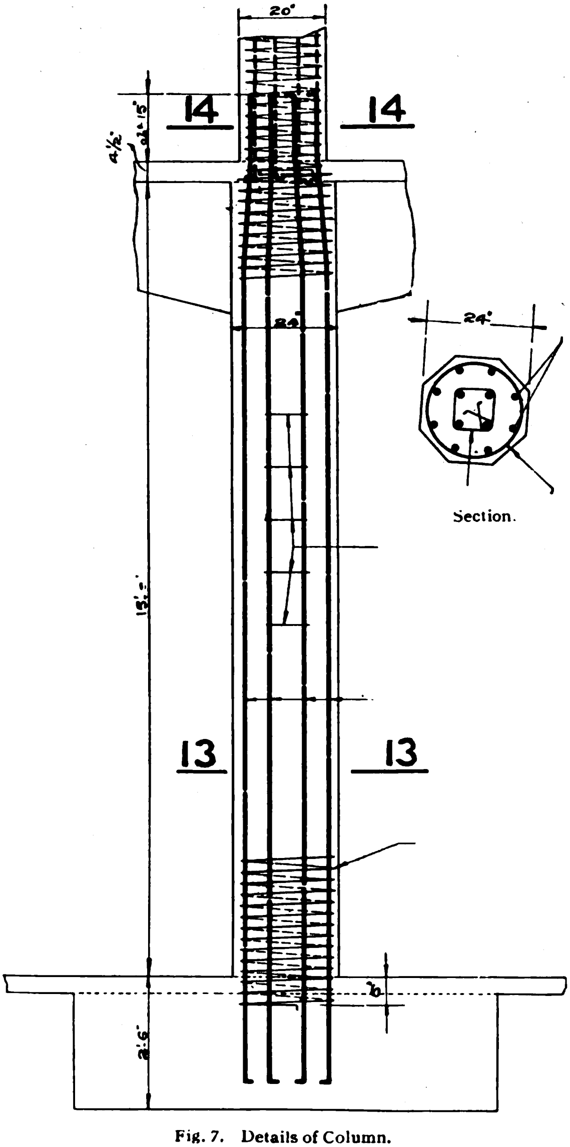
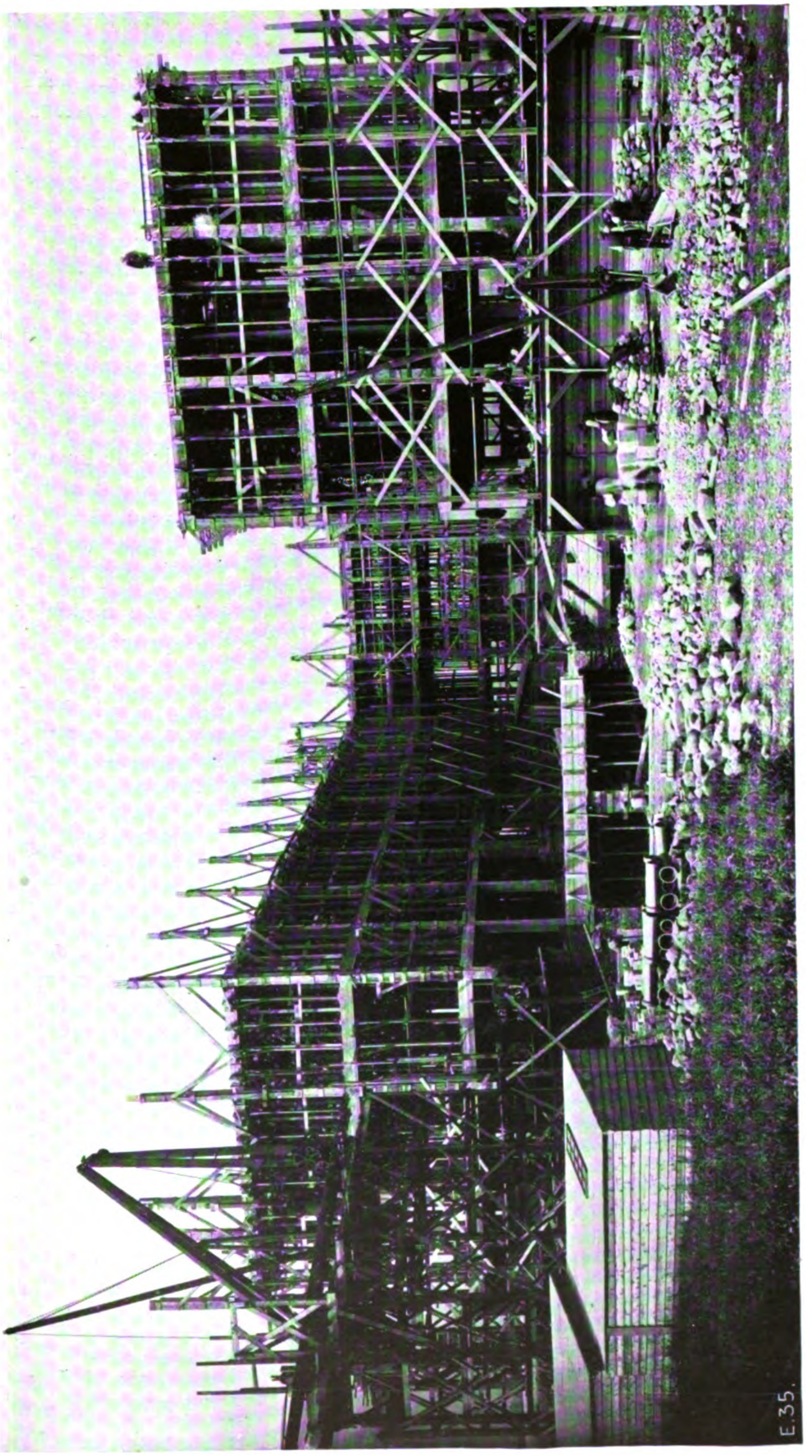


Fig. 7. Details of Column.
THE WALLACE-SCOTT TAILORING INSTITUTE, GLASGOW.

The main roof is designed in a similar manner to the floors, but with slabs only 3½ in. thick and with smaller size beams on account of the loads being smaller. The connecting corridors are roofed with concrete 4 in. thick, curved to a radius of 7 ft., and reinforced with curved and longitudinal rods placed in the centre of the thickness.

The staircases are constructed of reinforced concrete, and a minimum thickness of 2 in. is provided at the intersection of tread and riser, and bars are provided in both directions in the soffit. In addition one transverse rod is placed in each nosing, and cranked rods are carried round these to follow the line of the tread and riser face. The ends of the flights are supported by beams across the staircase well at the floor and landing levels.

A detail of the reinforced concrete bridge which was constructed across the River Cart is shown in *Fig.* 8, and this has a span of



View showing Side Wings under construction.
THE WALLACE-SCOTT TAILORING INSTITUTE.

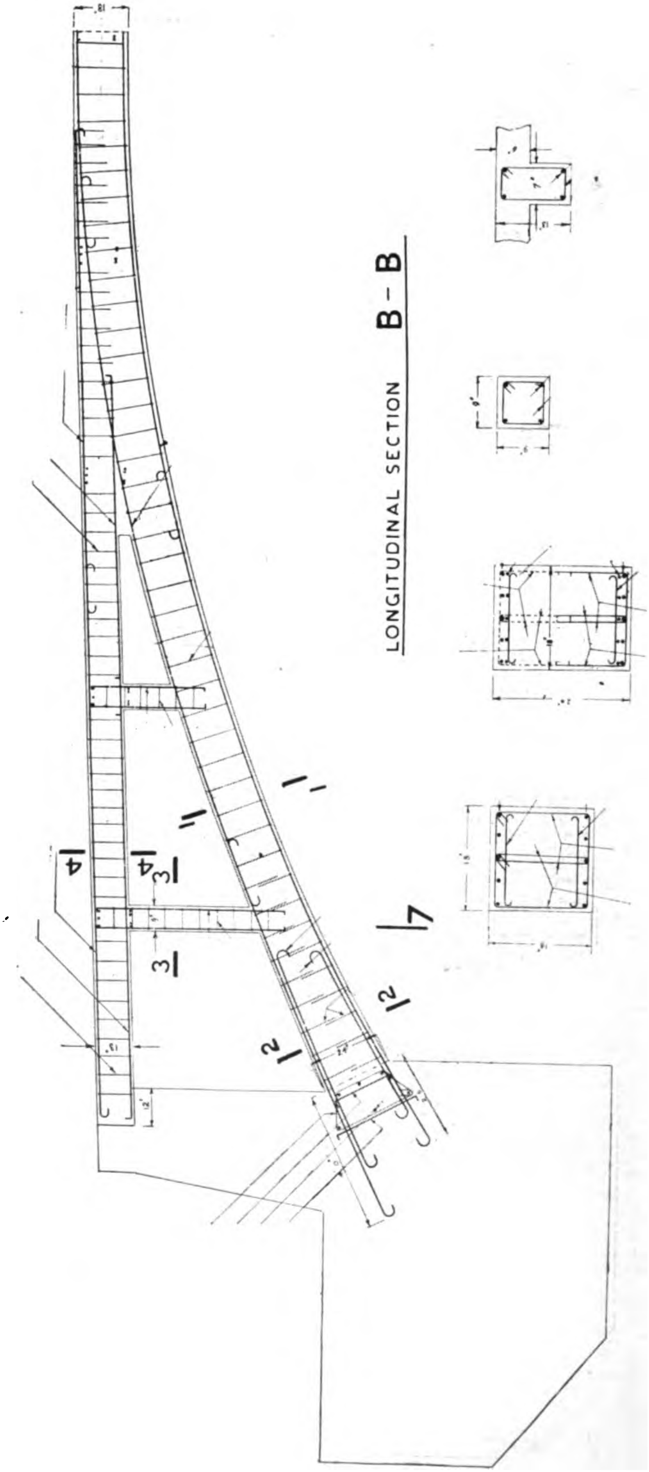


Fig. 8. Details of Bridge over River Cart.
The Wallace-Scott Tailoring Institute, Glasgow.

60 ft. clear between the abutments. The decking is formed with reinforced concrete 6 in. thick, with longitudinal and transverse rods in the lower surface and longitudinal bars in the upper surface, and under this are transverse beams, 16 in. deep and 7 in. wide, with four bars in the lower surface, spaced at 6 ft. 6 in. centres. The maximum width of the bridge is 18 ft., and two arched ribs are provided at 12 ft. 6 in. centres, these having a depth of 18 in. at the crown, increasing to 24 in. at the abutment, with a thickness of 18 in. and reinforced with bars in both upper and lower surfaces. The bridge is of the open spandril type, and short struts, 9 in. square, are formed over the back of the arched rib at the points where the transverse beams, above referred to, occur, and beams are also introduced at the higher level immediately above the main ribs, these being 13 in. deep and 7 in. wide and coinciding at

the top with the level of the decking. The transverse beams are continued out beyond the line of these last beams, and act as cantilevers to carry the decking and parapets. The arch has a rise of 8 ft. at the centre, and the abutments are formed with masses of plain concrete having a maximum width of 12 ft. and a thickness of 8 ft. 6 in.

The retaining wall which was constructed adjacent to the river at the lower end of the site has a height of about 13 ft., and this is formed with panels 5 in. thick and counterforts at 8 ft. centres. The panels have a batter of 1 in 12, and they are reinforced with horizontal and vertical bars in both surfaces. The counterforts are 5 in. thick, and a beam 12 in. wide and 6 in. thick is formed at the top of the wall connecting these.

The foundation consists of a reinforced slab, 6 in. thick, arranged with a heel projecting about 4 ft. from the back of the slab, and a small splayed toe having a projection of 9 in. The heel is finished with a reinforced beam 16 in. deep and 6 in. wide, and the counterforts extend from the extreme projection of the heel splayed back to the beam at the top. This wall is of a very economical type, containing as it does the minimum material consistent with the strength required, and it forms an excellent example of scientific design.

The contractors for the work were Messrs. Melville, Dundas and Whitson, of Glasgow.

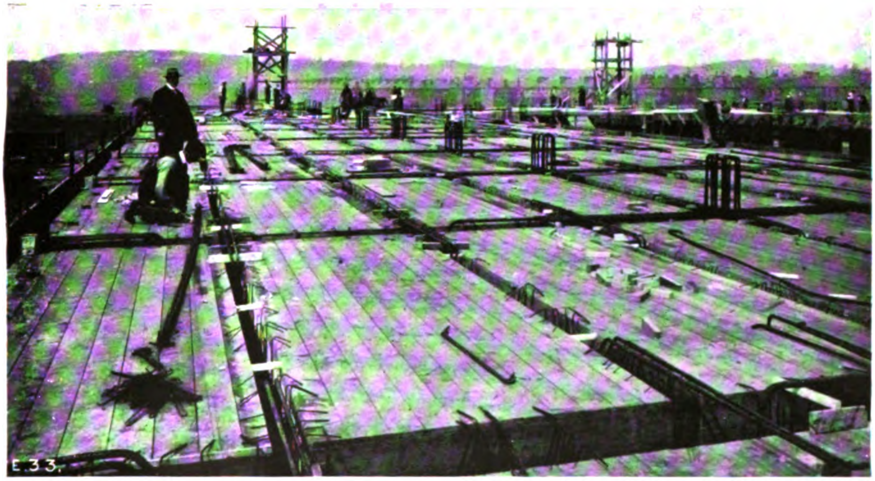


Fig. 9. Showing Floor Construction.
THE WALLACE-SCOTT TAILORING INSTITUTE, GLASGOW.

THE ELASTICITY OF COMPOUND BARS; WITH SPECIAL REFERENCE TO REINFORCED CONCRETE COLUMNS.

By HERBERT G. TAYLOR, M.Sc., A.M.I.Mech.E.

The following article will probably be of interest to those studying the question of the elasticity of compound bars.—ED.

1. By a compound bar is meant any portion of a structure which is compounded of two or more materials. The commonest application to engineering is the case of reinforced concrete where bars of steel are embedded in concrete in such a way as to form one solid member.

Before proceeding to the examination of the special problem of reinforced concrete we must deal with a few general principles of compound bars.

Members subjected to direct stresses, tension or compression. Consider two bars (1) and (2), as shown in *Fig.* 1, rigidly attached to each other. Let the cross sectional areas be A_1, A_2, and their moduli of elasticity be E_1, E_2 respectively. Write f_1 and f_2 for the stresses; then evidently the load is equal to the sum of the forces on the two bars; thus

$$P = f_1 A_1 + f_2 A_2 \qquad (1).$$

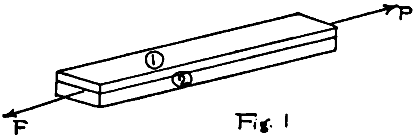


Fig. 1

Since the bars are rigidly attached the distortion is the same for each, that is, the strains are equal.

The strains of the bars are given by

$$e_1 = \frac{f_1}{E_1}, \text{ and } e_2 = \frac{f_2}{E_2}$$

respectively. But $e_1 = e_2$; therefore

$$\frac{f_1}{E_1} = \frac{f_2}{E_2} \qquad (2).$$

Equations (1) and (2) give the solution to any case of this type.

2. *The self-stressing of a compound bar when one element of the bar suffers a permanent change of length due to expansion or contraction on account of age.*

Suppose the bars (1) and (2), *Fig.* 2, be joined together when of equal length. Suppose that the bar (1) is of such a nature that, when separate from the second element, it would suffer a change of length due to contraction of an amount β per unit length.

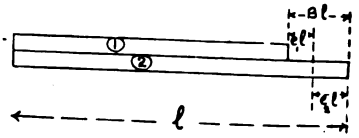


Fig. 2

Approach the problem thus: Let (1) have contracted freely an amount Bl. Then imagine that the ends of the two bars are again made coincident; the bar 1 suffering an extension $e_1 l$; and the bar 2 a contraction of amount $e_2 l$.

From the figure we have

$$e_1 l + e_2 l = \beta l,$$

or

$$e_1 + e_2 = \beta;$$

i.e.

$$\frac{f_1}{E_1} + \frac{f_2}{E_2} = \beta \qquad (1).$$

Again, since the total force in each bar is the same, therefore

$$f_1 A_1 = f_2 A_2 \qquad (2).$$

Equations (1) and (2) give the solution to any particular problem.

3. *Stresses produced by change of temperature in a simple bar.*

When a bar is heated it expands, and when cooled contracts. The change of dimensions per one degree of temperature is known for different materials. If, whilst receiving heat, a bar is prevented from expanding, or *vice versâ*, stresses will be set up in the bar.

Let the coefficient of expansion of a given bar per degree Fahrenheit be α; and let a bar, of length l and temperature t_1, be prevented from contracting whilst its temperature is reduced to t_2.

Under normal conditions of cooling the contraction would have been

$$l\alpha(t_1 - t_2).$$

Since contraction is prevented, this means that the ultimate condition of the bar would have been arrived at had it been maintained at the lower temperature and stretched by this amount. That is, the strain in the bar is

$$\frac{l\alpha(t_1 - t_2)}{l} = \alpha(t_1 - t_2) \qquad (1).$$

From this the stress can be readily deduced from a knowledge of the value of E.

If, in this case, the contraction is not wholly prevented, but the supports yield by an amount z, then the strain in the bar is given by

$$\frac{l\alpha(t_1 - t_2) - z}{l} \qquad (2).$$

4. *Stresses in a compound bar produced by changes of temperature.*

If a compound bar similar to that of *Fig.* 3 be heated, and at the same time be prevented from bending, then mutually induced stresses will be set up in the bars due to their different coefficients of expansion. Thus, imagine two bars, C and S, to lie side by side and to be of equal lengths at a certain temperature. On heating, let the extensions be a_c and a_s respectively, as shown, *Fig.* 3. Under the conditions of a compound bar the ends remain coincident; therefore the bar C must suffer an extension of amount which may be represented by x_c; and S a compression represented by x_s. The total force exerted by one bar is equal to that exerted by the other. Let l be the initial length of the bars at temperature t_2 and let heat be applied until the temperature is t_1. Let A be the areas, and α the coefficient of expansion for the respective bars denoted by a suffix.

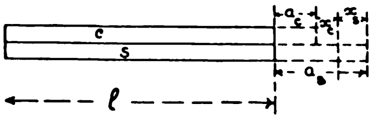


Fig. 3.

Thus at temperature t_1, $a_c = l\alpha_c(t_1 - t_2)$

and

$$a_s = l\alpha_s(t_1 - t_2).$$

Now

$$x_c + x_s = a_s - a_c \qquad (1)$$

from the figure; and, since the total force in each bar is the same,

$$\frac{x_c}{l} E_c A_c = \frac{x_s}{l} E_s A_s \qquad (2$$

(since $\frac{x}{l}E = f$, and fA = total force in the bar).

Equations (1) and (2) give the solution to any particular problem.

5. *The case where the materials of a compound bar become detached from each other.*

Suppose we imagine two bars, C and S, *Fig.* 4, to be arranged so that the material of C encircles the material S (the same arrangement as the steel reinforcement (S) within a concrete column (C); suppose, further, that the two materials are free from each other and that they stand on a rigid base shown. Let the two bars have equal lengths (l) at temperature t_2. The problem is: Given a load W applied to the compound bar, the bar being of the nature of a strut, what proportion of the load is supported by the respective elements after the temperature has risen to t_1? Also at what temperature will either of the elements cease to bear any load?

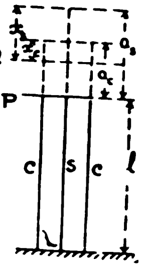


Fig 4.

Approach the problem in this manner: At t_2 the lengths are equal. Apply heat until the temperature is t_1; then apply the load W with the stipulation that finally the lengths of the bars are equal.

Let the line P be drawn at the head of the bars at the lower temperature. On heating the heads of the bars rise by

$$a_s = \alpha_s(t_1 - t_2)l, \text{ and } a_c = \alpha_c(t_1 - t_2)l$$

respectively, as shown. The applied load brings the heads again to equal levels at the line Q; x_s and x_c being the respective deformations due to compression.

From the figure we have $$a_s - x_s = a_c - x_c,$$

i.e., $$\alpha_s(t_1 - t_2)l - x_s = \alpha_c(t_1 - t_2)l - x_c;$$

from which $$\frac{x_s}{l} = (\alpha_s - \alpha_c)(t_1 - t_2) + \frac{x_c}{l} \qquad (1).$$

Again $$f_s A_s + f_c A_c = W,$$

or $$\frac{x_s}{l} E_s A_s + \frac{x_c}{l} E_c A_c = W \qquad (2).$$

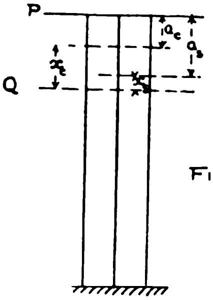


Fig. 5

If there had been a fall of temperature of the same amount the above investigation would have been based on

$$a_s + x_s = a_c + x_c \qquad (3)$$

as will readily be seen from *Fig.* 5.

By means of (1) and (2) the values of x_s and x_c are determined; then the component parts on the left of (2) can be severally arrived at; that is the values of the respective portions of the load borne by the two elements.

6. *The temperature at which the bar C (Fig. 4) will be free from stress.*

This happens when, proceeding on the same lines as before, the difference between $\alpha_s l$ and $\alpha_c l$ is so great that the subsequently applied load W produces compression in S in such a way that S just bears the whole load at the instant when contact is just taking place with the head of the material C. This can be investigated in the same way as before; or otherwise by putting $x_c = 0$ (this is the condition for no stress in C) in § 5 (1) and (2). We then have these two equations from which to obtain t_1:

$$\frac{x_s}{l} = (a_s - a_c)(t_1 - t_2) \qquad (1)$$

$$\frac{x_s}{l} E_s A_s = W \qquad (2).$$

Now let us see how these propositions apply to reinforced concrete columns.

7. The degree of importance of this investigation will depend entirely upon the difference in value between the coefficients of expansion of steel and of concrete; and so this point calls for first consideration. Many experimenters have been engaged upon the task of determining these coefficients, and the values they find vary considerably, particularly for concrete. The collected values given by Buel and Hill are as follows :—

Coefficients of expansion.	
Concrete.	**Steel.**
·00000545	·00000648
655	686
795	617
	676

Other writers give similar collected results. Now it so happens that the mean values of the coefficients for steel and concrete in the above table (and in other collected results) are almost equal to each other. It does not, however, follow that the mean value is the true one. For example, the mean value for concrete in the table above is ·00000655. If this were the correct value or the value which differs very slightly from the correct value, then the other two values given are in error by about 21 per cent. From a physics research point of view this is an absurdity. It thus appears that if the figures given have any value at all they must each be correct for the particular brand in the test to within 1, or, at most, 2 per cent. The same remarks apply in a less degree to steel. It is, therefore, evident that different qualities of concrete have widely divergent coefficients of expansion, due, probably, to quality of cement, nature of sand or gravel, method of mixing, and age. Similarly with regard to steel. Hence in any given structure it is possible to have concrete with a coefficient of expansion of ·00000545 and steel with ·00000686, or any other combination of values.

8. *Reinforced concrete column.*

The effects produced in a reinforced column can be most clearly shown by a worked example. The general theory is completely given in the foregoing paragraphs.

Let us suppose, therefore, that we have a column of 100 square inches in sectional area containing a simple reinforcement of four steel rods each 1 in. square section.

That is, area of concrete = 96 sq. in., area of steel = 4 sq. in.

We shall also take

Modulus of elasticity for steel (E_s) = 30,000,000 lb. per sq. in.
Modulus of elasticity for concrete (E_c) = 3,000,000 per sq. in.
Coefficient of expansion for steel (α_s) = ·0000069 per °F.
Coefficient of expansion for concrete (α_c) = ·0000054 per °F.

The numerical value of the length of the column is immaterial, since the term l comes into every quantity involved; therefore, we will consider unit length. The column is built; the rods and concrete finished off flush at the top and bottom; the concrete adheres to the steel and sets. After setting contraction of the concrete begins to take place, which, in a free specimen, is of amount ·0003 to ·0005 of the original length.*

The elements of the column, therefore, become self stressed before any load is applied.

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* Considère : Reinforced Concrete. The Concrete Institution give ·0002 to ·0005 at one month old ·0004 to ·0006 at 1½ years old.

Examine the case so far. Take the mean value, viz., ·0004, as the contraction. Using equations (1) and (2) § 2, viz. :—

$$\frac{f_c}{E_c}+\frac{f_s}{E_s}=\beta$$

and

$$f_cA_c=f_sA_s;$$

we find, on substitution,

$$\frac{f_c}{3\times10^6}+\frac{f_s}{30\times10^6}=\cdot0004,$$

and

$$96f_c=4f_s;$$

from which $f_c=$ 353 lbs. per sq. in.

and $f_s=8470$ „ „

the concrete being in tension and the steel in compression.

Now the amount of strain produced by this stress in the concrete is given by

$$\frac{f_c}{E_c};\ i.e.,\ \frac{353}{3{,}000{,}000}=\cdot000118.$$

According to Professor Turneaure ("Proceedings American Society for Testing Materials, 1904") concrete will stretch ·0001 to ·0002 of its length before showing minute cracks or "water marks." It would therefore appear, in the case under consideration, that at this stage the concrete had already begun to show cracks; that is, before being subjected either to load or to changes of temperature.

9. What will happen subsequently when the column is subjected either to load or changes of temperature will depend on the distribution of the cracks. If the cracks are at fairly short and regular intervals the adhesion between the steel and concrete may be overcome, as will be seen, as follows :

The ultimate adhesive force between steel and concrete is given by Christophe (Beton Armé) as 275 lb. per sq. in. In the case under consideration this gives a force of 4 × 275 = 1,100 lb. per in. run of rod (since each rod exposes 4 sq. in. of area per in. run). Now since the force in the rod is 8,470 lb., this means that the rod will burst itself endwise from a slab of concrete of thickness 15 in. (measured along the axis of the column), as shown, thus :—

$$\frac{8470}{1100}=7\cdot7\text{ in.}$$

And steel 15 in. long would force itself from either one half or the other of the concrete block (see *Fig.* 6). When one half is free the other half, in a similar way, would free itself, and so on, by subsequent bisections (in theory, *ad infinitum*) the adhesion between concrete and steel would ultimately be overcome.

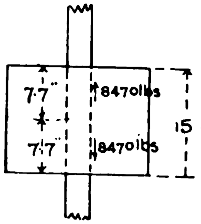


Fig 6.

In this case, then, if the cracks are spaced at 15 in. apart, the adhesion would cease and the concrete would simply hang loose upon the steel rods, and the behaviour of the bar would be a matter for conjecture. It would probably be a similar case to that of § 5, both elements in the unloaded state being unstressed. Therefore, consider the column to be the compound bar of that article. On the assumptions made in § 1, *i.e.*, that the temperature effect was negligible, the load on the column, assuming 400 lb. per sq. in. on the concrete and 4,000 lb. per sq. in. on the steel (since $f_s=f_c\frac{E_s}{E_c}$, § 1), would be

$$96\times400+4\times4{,}000=54{,}400\text{ lbs.}$$

10. Suppose, now, that the temperature changes from 40° to 100° F., and let us see what difference in the distribution of stresses and loads is made on the consideration of the effect of the different expansions of the two materials.

Substituting known values in § 5 (1), we find

$$x_s = (\cdot0000069 - \cdot0000054)\,60 + x_c,$$

i.e., $$x_s = \cdot00009 + x_c;$$

and substituting this in § 5 (2) we find

$$(\cdot00009 + x_c) \times 30 \times 10^6 \times 4 + x_c \times 3 \times 10^6 \times 96 = 54{,}400;$$

whence $$x_c = 107 \times 10^{-6},$$

and hence $$x_s = 197 \times 10^{-6}.$$

Substituting these in the respective xE of § 5 (2), we find

Stress on concrete = 321 lb. per sq. in.
Stress on steel = 5,910 lb. per sq. in.,

both being in compression, as compared with the values assumed above of 400 and 4,000 respectively, which would have occurred had there been no temperature effects.

If the temperature falls by 60° F., then, by the method indicated in § 5 (and which is very similar to the above), we find

Stress on concrete = 480 lb. per sq. in.
Stress on steel = 2,100 lb. per sq. in.,

both being in compression.

11. A further point of investigation arising here is: At what temperature will the steel bear all the load and the concrete be free from stress?

This happens, as outlined in § 6, when using § 5 (1) and (2) and substituting $x_c = 0$,

$$x_s = (\alpha_s - \alpha_c)(t_1 - t_2) = \cdot0000015(t_1 - t_2);$$

i.e., $$\cdot0000015(t_1 - t_2) \times 30 \times 10^6 \times 4 = 54{,}400;$$

hence $$(t_1 - t_2) = 302^\circ \text{ F.}$$

That is, the rise of temperature required is 302° F. (See the remark about chimneys in § 16).

The corresponding stress in the steel is

$$f_s = x_s E_s = \cdot0000015 \times 302 \times 30 \times 10^6;$$

whence $$f_s = 13{,}590 \text{ lbs. per sq. in.}$$

12. If cracks are not formed in the column the subsequent behaviour under load and changes of temperature would be that of a compound bar, such as is treated in §§ 1 and 4. Therefore, assuming this to be the case, we have: The initial stresses before the load is applied are (see § 8):—

Concrete (tension) = 353 lb. per sq. in.
Steel (compression) = 8,470 lb. per sq. in.

Suppose, as before, that a load of 54,400 lb. is applied to the column. Applying equations (1) and (2), § 1, we have

$$54{,}400 = f_s \times 4 + f_c \times 96,$$

and $$\frac{f_s}{30 \times 10^6} = \frac{f_c}{3 \times 10^6};$$

whence (and since the case is the reverse of that already worked in § 10) we have

$$f_s = 4{,}000 \text{ lb. per sq. in.}$$

and $$f_c = 400 \text{ lb. per sq. in.},$$

both being in compression.

These stresses are superimposed on the initial stresses (caused by shrinkage of the concrete), giving the results:—

Concrete = 400 − 353 = 47 lb. per sq. in.
Steel = 8,470 + 4,000 = 12,470 lb. per sq. in.,

both stresses being compressive, being a very remarkable result. The resultant stress thus produced in the concrete would prohibit cracks appearing. Any subsequent change of temperature will produce stresses which are further superimposed. Thus, as before, let us assume the above represents the conditions at a temperature of 40° F., and that the temperature of the structure subsequently rises to 100° F.

13. The behaviour of the bar will be similar to that dealt with in § 4, therefore, using the equations deduced therein and referring to *Fig.* 3, we have

$$a_c = \alpha_c(100-40)$$

$$\therefore\ a_c = {\cdot}0000054 \times 60 = {\cdot}000324\,;$$

and

$$a_s = \alpha_s(100-40)$$

$$\therefore\ a_s = {\cdot}0000069 \times 60 = {\cdot}000414.$$

Again

$$x_c + x_s = a_s - a_c$$

$$\therefore\ x_c = {\cdot}000009 - x_s \qquad (1).$$

Further, by equation (2) § 4,

$$x_c \times 3 \times 10^6 \times 96 = x_s \times 30 \times 10^6 \times 4,$$

i.e.,

$$x_c = \frac{5}{12}x_s\,;$$

and substituting from (1) above we find

$$\left.\begin{array}{l} x_c = {\cdot}0000265 \\ x_s = {\cdot}0000635 \end{array}\right\} \qquad (2).$$

Again, since

$$f = xE,$$

we find

$$f_c = {\cdot}0000265 \times 3 \times 10^6$$
$$= 79{\cdot}5 \text{ lb. per sq. in., tension;}$$

and

$$f_s = {\cdot}0000635 \times 30 \times 10^6$$
$$= 1{,}905 \text{ lb. per sq. in. compression.}$$

The resultant stresses are then as follows (see § 12):—

Concrete 79·5 − 47 = 32·5 lb. per sq. in. tension
Steel 12,470 + 1,905 = 14,370 lb. per sq. in. compression.

(It is obvious that the concrete, in changing from compression to a state of tension, has passed through a state of zero stress; if desired, the temperature at which this happens can be determined by means of § 6.)

14. If there had been a fall in temperature of 60° F. we should have had

$$f_c = 79{\cdot}5 \text{ lb. per sq. in. compression}$$

and

$$f_s = 1{,}905 \text{ lb. per sq. in. tension,}$$

giving resultant stresses thus:—

Concrete = 79·5 + 47 = 126·5 lb. per sq. in. compression
Steel = 12,470 − 1,905 = 10,570 lb. per sq. in. compression.

Another point arises here: Before any temperature change is suffered the stress in the concrete, as seen above, is 47 lb. per sq. in. compression. This means a compressive strain of $\frac{47}{3 \times 10^6} = 16 \times 10^{-6}$. Now the point is: At what temperature will the concrete be sufficiently in tension to show cracks, and what will then be the stress in the steel?

15. We have previously seen that cracks begin to appear at strains ·0001 or ·0002 (see § 8). Assuming the latter value as the criterion we have the strain to be produced before cracks begin to appear :—

$$x_c = \cdot 0002 + \cdot 00000016\,;$$

by which we see that the initial deformation may be neglected. Therefore, using ·0002, by § 4 equation (2) we have

$$\cdot 0002 \times 3 \times 10^6 \times 96 = x_s \times 30 \times 10^6 \times 4,$$

whence $$x_s = \cdot 00048.$$

Again by § 4 (1), we have

$$\begin{aligned} \cdot 0002 + \cdot 00048 &= a_s - a_c \\ &= (\alpha_s - \alpha_c)(t_1 - t_2) \end{aligned}$$

$$\therefore\ \frac{\cdot 00068}{\cdot 0000015} = (t_1 - t_2)\,;$$

whence, the rise of temperature required is $(t_1 - t_2) = 450°$ F.

The stress in the steel thus produced is

$$\begin{aligned} f_s = x_s E_s &= \cdot 00048 \times 30 \times 10^6 \\ &= 14{,}400 \text{ lbs. per sq. in.} \end{aligned}$$

i.e., a resultant stress of (see § 11) 12,470 + 14,400 = 26,870 lb. per sq. in. compression.

This would mean that, according to the argument of § 9, the steel would slip away and become detached from the concrete provided that the cracks were at a distance apart of about 20 × 2 = 40 in., as seen thus: Of the 26,870 lb., 4,000 lb. is due to load, the difference, 22,870, is due to mutually induced stresses between steel and concrete; therefore, by the argument of § 9, we have

$$\frac{22{,}870}{1{,}100} = 20 \text{ in.}$$

16. This last problem has a special reference to reinforced concrete chimneys, and its importance can be gathered by reference to a note in *Engineering*, April, 1913, p. 575, which says that reinforced concrete chimneys begin to show body cracks if the interior be heated to 500° F. The foregoing is probably some explanation of this phenomenon.

The two outstanding features of this article are the effects of the contraction of the concrete due to setting, and the effect produced by the fact that the coefficients of expansion of the materials are different.

The first of these points cannot be eliminated, so it requires serious consideration and should be taken into account in design.

The second point becomes negligible if the coefficients of expansion of steel and concrete are nearly equal to each other. The ideal condition is when the coefficients are equal, but this probably cannot be attained owing to the changing nature of concrete with age. It thus appears important that every brand of concrete should be tested for expansion alongside the steel with which it is to be used in conjunction; also for any given specimen of concrete the possible variation over a considerable period should be known.

17. The subjoined table is a summary of the results obtained in the text together with another case of the opposite type. Case I. is the collected results from the text using coefficients of expansion in which that of steel exceeds that of concrete by ·0000015. Case II. is another case where the coefficient for concrete exceeds that of steel by ·0000015. Note that the difference of coefficients in either case is the same, hence the identity in some instances and the reversal in others of the values given in the table.

SUMMARY OF RESULTS.

$A_s = 4$ sq. in. $E_s = 30 \times 10^6$ lb. per sq. in.
$A_c = 96$ „ „ $E_c = 3 \times 10^6$ „ „ „

Case I, worked out in text		Case II.
·0000069 per °F.	α_s	·0000065
·0000054 „ „	α_c	·0000080

PROCESS.		Stresses, lb. per sq. in.			
		In the process.		Net.	
		Steel.	Concrete.	Steel.	Concrete
The case in which cracks are formed. § 8.					
Contraction of concrete in setting. § 8. Cases I. and II.		+8,470	—353	+8,470	—353
Application of load. § 10. Cases I. and II.		+4,000	+400	+4,000	+400
Temperature increases by 60° F.; still supporting load. § 9	Case I.	+5,910	+321	+5,910	−321
	Case II.	+2,100	+480	+2,100	+480
Alternative: Temperature decreases by 60° F.; still supporting load. § 9	Case I.	+2,100	+480	+2,100	+480
	Case II.	+5,910	+321	+5,910	−321
Change of temperature required to relieve the concrete from stress. § 11	Case I.	302° F.			
	Case II.	—302° F.			
Stress in steel to accomplish this. § 11. Cases I. and II.		13,590			
The case in which cracks are not formed. § 12.					
Contraction of concrete in setting. § 12. Cases I. and II.		+8,470	—353	+8,470	—353
Application of load. § 12. ... ...Cases I. & II.		+4,000	+400	+12,470	+ 47
Temperature increases by 60° F.; still supporting load. §13.	Case I.	+1,905	—79·5	+14,370	— 32·5
	Case II.	—1,905	+79·5	+10,570	+126·5
Alternative: Temperature decreases by 60° F.; still supporting load. § 14	Case I.	—1,905	+79·5	+10,570	+126.5
	Case II.	+1,905	—79·5	+14,370	— 32·5
Change of temperature required to stress the concrete to cracking point. § 15. ...	Case I.	+450° F.			
	Case II.	—450° F.			
Stress in steel to accomplish this. Cases I. & II.		+26,870			

N.B. + is compression, — is tension.

THE CONCRETE INSTITUTE.

PRESIDENTIAL ADDRESS.

By Prof. HENRY ADAMS, M.Inst.C.E.

The Concrete Institute started its new Session on November 19th, when the Presidential Address was delivered by the newly-elected President. We give the Address below, together with a short account of the discussion which followed.—ED.

INTRODUCTION.

THE President, in his opening remarks, expressed his appreciation of his election by the Council. This, he stated, is in accordance with the custom which has obtained since its inception. He said he would rather see the nomination of President and Vice-Presidents submitted to the vote of the general body of members. This is under consideration, and he hoped that the various alterations in the Articles of Association now under consideration would include some means whereby the members all over the world can take part in the elections, not only of the chief officers, but of the entire Council.

The President then dealt briefly with the membership of the Institute and the effect of the war on the same. Reference was made to the library and financial position.

The address then deals with the L.C.C. Regulations on Reinforced Concrete and the work of the Institute in regard to same. He stated that out of eighty-seven suggestions made by the Institute sixty-five have been adopted, and that it is hoped in the final revision a good proportion of the outstanding balance would still be included. He also made reference to the calculations for bending moments and the proposed changes by the L.C.C.

The second part of the address then goes on to deal with different aspects of reinforced concrete construction.

FAILURES IN REINFORCED CONCRETE.

If the Concrete Institute has emphasised one thing more than another in connection with the materials the members are interested in, it is the necessity for the best possible workmanship and the utmost care in supervision. The majority of the failures that have occurred have been due to improper materials or careless workmanship.

In my remarks upon the subject at the International Congress of Architects eight years ago I paraphrased the old saying that "nothing succeeds like success" by "nothing succeeds like failure," because I believe that a proper study of failures will do more than anything else to ensure success. In 1912 the Concrete Institute formed an "Investigation Committee" for the purpose of studying failures as they occurred, but the natural desire of all parties concerned to hush up the failures has prevented the Committee so far from doing much useful work, unless the fact of its existence acts as a bogey to frighten the careless operative. It may be well to remind you that a schedule has been drawn up for recording the details of such failures as are brought to the notice of any member, and all such schedules are treated as confidential by the Committee unless permission is given by the parties concerned to make public use of them.

The scientific principles of reinforced concrete and structural mechanics are now so well known that the failures due to ignorance on the part of the designer are conspicuous by their absence, but frequently there are failures reported which are due to the formwork being badly designed and fixed, or removed too early. Too often these matters are left to the foreman carpenter, and however conscientious he may be his goodwill is no substitute for experience. *Festina lente* (" Make haste slowly ") is, I think, an exceptionally good motto for us and our work. Near Auburn, California, a reinforced concrete bridge in three spans was under construction towards the end of last year. The work was being rushed day and night by the contractors in order that it might be finished before the river rose, and on the night of November 4th the formwork under one end span collapsed, allowing the whole mass to fall, killing some of the workmen and injuring several others.

In engineering works, such as reservoir dams, other causes of failure have been found, one of the most remarkable of which is the action of alkali on concrete.

STRENGTH OF REINFORCED CONCRETE.

A curious objection has been taken to building in reinforced concrete, which is that it is so difficult to pull down. It is frequently said that it costs more to destroy a building than it does to put it up. It must be admitted that this method of building does not lend itself readily to alterations; and although I have not personally come across a case where this has been a serious matter, there is a recent instance in Germany where some concrete vaults which had to be removed cost twice as much to destroy as they had cost to build. In some other cases it has been found that only by recourse to blasting operations has it been possible to break up the work in this material, but the imperishable character of the structure and the small cost of upkeep are really very great points in its favour. Their inherent strength and the nature of their stability render these buildings peculiarly suitable to withstand vibration, and even earthquake, whereas ordinary construction is only stable while at rest, and the slightest earth tremors may have a disastrous effect.

FIRE RESISTANCE OF REINFORCED CONCRETE.

Brickwork is one of the best fire-resisting materials, but a building cannot be erected in brickwork alone, and considerable loss of life has occurred in fires from the walls falling as they ceased to receive the support of the floors and roofs. Reinforced concrete, on the other hand, can be used not only for the walls but for the floors and roofs also, and the steelwork, which is often the cause of the greatest danger in a brick building, is so protected by the concrete that the fire has practically no effect upon it. Limestone must not be used in the aggregate, as that burns to pure lime in a fire and swells and disintegrates when water comes upon it. Coke breeze as an aggregate was found to stand fire well in the experiments made by the British Fire Prevention Committee, and for that reason has been largely used by architects, but coke breeze has sometimes a deleterious effect upon the steel reinforcement, and is liable to swell in damp situations or if water reaches it. An indication of the value of reinforced concrete is given in the fact that a lower premium is asked by the Fire Insurance Committee for buildings in this material providing the floors are not less than 5 in. thick and the walls not less than 6 in. thick.

CRACKS IN CONCRETE.

It will be interesting to look back upon some of the troubles that faced the early workers in reinforced concrete and to see how such troubles have been surmounted. One of the most frequent difficulties found in the early days of reinforced concrete building was the occurrence of cracks in the finished work. Some of these were undoubtedly due to over-limed cement and to coarse grinding, but the improvement effected by the publication of the Standard Specification of Portland Cement and the endeavour of manufacturers to keep up with it, and even to surpass it, have virtually eliminated this cause of trouble.

A still frequent cause of cracking is shrinkage upon the drying out of the moisture, but a remedy for this has been found in what is called "temperature reinforcement," which consists of the insertion of light rods, say ¼-in. diameter, and not more than 12 in. apart in the opposite direction to the main reinforcement and near the surface, whereby the shrinkage, being confined within these limited areas, is so slight as to be invisible. Other causes are sudden changes of thickness, changes in the composition of the concrete, local currents of air upon the concrete while setting, insufficient reinforcement allowing deformation to occur, etc. Where the new surface is exposed to the sun the changes of temperature are apt to cause "crazing," particularly where the surface skin is richer in cement than the body of the work. The best remedy for this is perhaps to brush the surface with hydrochloric acid and then wash it with clear water.

UNIFORMITY IN LARGER AGGREGATE.

Another cause of early difficulty was the uniformity in size of the larger aggregate. When the maximum of 1½ in. was reduced to 1 in. it was thought that this would be effective in producing solid concrete capable of being packed closely round the reinforcement, but tests showed that it was necessary to grade the aggregate from ¼ in. to ¾ in. to make sure of obtaining a solid concrete without voids and in perfect contact with the steel. In the same way the sand was found to produce better work when it was not of uniform size, but graded from 1-50 in. to $\frac{3}{16}$ in. As the cement has to envelop every particle of the aggregate, and cement one to the other, the grading involves the use of a smaller quantity of cement as the voids are small, and also reduces the waste of aggregate, as nothing but dust has to be thrown away.

STANDARDISATION OF EXPERIMENTS WITH CONCRETE.

Much valuable work has been practically lost because of the difficulty of coordinating experiments made with different materials under varying circumstances. An important suggestion has been made by one of our members, Mr. John A. Davenport, that for some time to come all experiments on reinforced concrete beams, columns, and similar structural members should be made on a standard steel and a standard concrete. By "standard steel" is meant one having a particular ultimate strength, yield point, elongation, and contraction; these could vary between limits, but the variation should be kept small. By "standard concrete" is meant one made of one particular coarse material, one particular sand, and one particular cement, always mixed in the same proportion with the same amount of water. The coarse material should always have the same sizes and grading, and the sand should likewise have definite sizes and grading which must always be the same. We should then be able to decide definitely many of the points which were the subject of lengthy discussions during the preparation of the Local Government Board Regulations—for example, what constituted fixed ends to beams, what width of floor slab should be taken as the flange of a T-beam, what was the actual economy of double reinforcement, how far a concentrated load might be considered to have spread by the time it reached the reinforcement, the comparative value of vertical and inclined shear stirrups, adhesion between the concrete and the reinforcement, the economical value of deformed bars, etc.

STANDARD SYSTEM OF MEASUREMENT.

A Joint Committee of the Concrete Institute and the Quantity Surveyors' Association have prepared a synopsis of a "Standard System of Measurement for Reinforced Concrete Work" which will greatly facilitate uniformity in the preparation of bills of quantities and reduce the risk of errors of misunderstanding and consequent disputes. The story of a remarkable blunder was related in the Chancery Division of the Law Courts on January 30th last, when the Commissioner of Works was allowed rectification of a contract with Messrs. W. King and Co., contractors. The Solicitor-General explained that the contract was for the construction of the Western District Post Office building in Wimpole Street. The contractors scheduled reinforced concrete at so much per cubic yard, and when the schedules were sent to be typewritten "yard" was altered to "feet," the effect being to alter the price from £20,000 to more than £133,000.

STANDARD SPECIFICATION FOR REINFORCED CONCRETE.

The Council have in hand a standard specification for reinforced concrete which is nearing completion, and if more uniformity in drafting specifications for such work can thereby be obtained there will be more certainty in the tendering and a greater absence of sporting items. The absence of immoderate or harsh clauses should lead not only to better work, but also to cheaper construction. In publishing a model specification, however, and in widely circulating the information contained in the papers read at the meetings there is some risk of encouraging incompetent men to attempt to prepare designs and carry through construction in reinforced concrete; but although such works would be likely to be small and insignificant, it cannot be pointed out too emphatically that success can only be obtained by employing men who have specialised in this class of work. At the Sixth Congress of the International Association for Testing Materials, held at New York in 1912, the question of universal standard specifications was mooted, but there seem to be insuperable difficulties in the way at present. It was suggested that when each country got its own perfect specification it would be time to compare them and arrive at a single result, but I am afraid we are a very long way yet from that happy end.

OBTAINING DESIGNS.

I think it may be useful for us to consider for a few minutes what is the usual method followed at present for obtaining the design for the structural parts of a reinforced concrete building and whether that method conduces to economy. The routine in most cases is for the architect to prepare an outline drawing showing the plan of each floor, with the cross walls, openings for doors and windows, and positions of stairways, lifts, etc., marking on it the loads to be carried and the height of each floor. He then obtains designs and estimates from a certain number of firms who devote themselves to this class of work, but are each identified with a particular detail of construction, and selecting the offer which he considers the most suitable and economical, completes his own designs, and puts them before his client for approval. Now the question is, Does this method lead to economy and security? The designs so obtained, being competitive, are naturally based upon the minimum requirements of safety, and leave no margin for accidental errors or faulty material or workmanship, and some of the failures may possibly be due to this cause. I do not intend this as any reflection upon the skill or honesty of the specialists who at present prepare the majority of the designs, but it is not in human nature to provide more than the bare necessity of the case demands when the success of the tender depends upon the cost being kept down to a minimum. The Institution of Civil Engineers has recently issued a circular deprecating the preparation of designs in competition. As a consulting engineer, I may perhaps be biassed, but I am of opinion that collaboration between the architect and the structural engineer is the preferable course, so that a single design may be prepared upon which contractors may tender upon a common basis. Against this it is often said that engineers' designs are expensive, and that there is no advantage in calling in an independent expert to prepare the design; but I think it will generally be found that the additional cost is due solely to a larger amount of reinforcement than appears in competitive designs, with the result that the building gains in greater stability.

There is another aspect of the case, and that is that when several designs are submitted the cost of the unaccepted designs has to be met somehow. It increases what we may call the establishment charges, which must be met by a percentage added to the actual cost of all work, and the only advantage appears to be that with many men working upon the same scheme some one among the many may evolve a better result than one man alone would be likely to do.

THE LOCAL GOVERNMENT BOARD.

The Local Government Board are responsible for retarding the progress of reinforced concrete to a very great extent. Many structures that would have been put up in that material have not even got so far as the design, because of the known opposition of the Board and the heavy expense thrown upon the promoters by reason of the short period for which a loan would be granted. They have fixed no actual periods for loans for the various classes of work, as each case is considered on its merits, having regard to the purpose of the work and its position, but they vary usually from ten years where the work is in contact with water to thirty years in the floors of a building.

If there were any reasonable doubt as to the probable duration of reinforced concrete structures in general, the Council of the Concrete Institute would be the first to know it, but they have the evidence of their own personal investigations that it exceeds fifty years, and they do not hesitate to advise its use where that is not hampered by the consideration of a loan through the Local Government Board. When the Eddystone Lighthouse was pulled down in 1884 a bundle of iron rods which had been accidentally left in the concrete foundation in 1757 (127 years) was found to be in perfect condition, and one would have supposed that was in a sufficiently exposed situation to prove the safety against corrosion.

Within my knowledge the construction of a large reinforced concrete seaside pier was quite recently abandoned after completion of the designs because the Local Government Board would only allow ten years for the repayment of a loan for its construction. In another case the Local Government Board refused to allow more than ten years for the repayment of a loan of £10,000 for a reinforced concrete storage-tank. The tank was then re-designed in mass concrete to cost £13,750, for which the Board allowed twenty-five years for the loan repayment, making the annual charge £880, as against £1,233, which would have been required for the less costly tank on the ten years' basis. Had twenty-five years been granted in the first case, the annual charge would only have been £640. Fortunately, there are many cases that do not depend upon official mercy. A sea wall, 300 ft. long, in reinforced concrete has just been erected at Carnarvon by the Harbour Trust in extension of an existing masonry wall, to afford increased wharfage for oil-tank steamers and to reclaim about two acres of the foreshore. The existing heavy masonry structure, 20 ft. high from shore to coping, rested on a foundation 6 ft. below shore level, and it was originally intended to construct the extension in a similar manner. There were many ingenious features in the design carried out, but the point I want to make is that the cost of this work in reinforced concrete was about £2,000, while the lowest tender for a masonry wall was £4,600. The corrosion of the reinforcing rods when the concrete is in contact with water, fresh or salt, continuously or intermittently, is only possible under exceptional circumstances.

A novel application of reinforced concrete has recently been made in the construction of a floating wharf in Sydney Harbour for berthing steamers on each side. The pontoon is 100 ft. long, 43 ft. wide at one end and 68 ft. at the other, 7 ft. 9 in. deep, with a 32-in. freeboard under full load. There are forty-eight watertight compartments, and the total dead weight is 650 tons. The live load allowed for is 150 tons. Apparently no fear of sea-water acting prejudicially upon the reinforcement troubles the minds of the promoters in this case.

STRUCTURAL ENGINEERING.

So much has been said lately about structural engineering and so many persons seem to be in doubt as to what is meant by it that I should like to devote a short time to its consideration. It is a great mistake to suppose that it consists of steel-framed buildings only; but is merely one branch of a very large subject. Reinforced concrete is another branch—a very large one, and possibly the main stem, at least for us. These two forms of construction will in the future, so far as we can foresee, constitute the chief work of the structural engineer, but buildings in other materials—wood, stone, and brick—come under the head of structural engineering when the chief object is stability. Bridges, towers, jetties, retaining walls, roofs, tanks, reservoirs, dams, and many other structures would come under this classification, and it is to enable us to deal with all these in our papers and discussions that the Council have endeavoured to broaden the scope of the Concrete Institute.

Bridges.—Bridges alone should be a fertile subject. So many examples have now been completed in reinforced concrete that we can form a fair idea of the value of that mode of construction. It has a distinct advantage over brickwork and masonry in being able to resist tensile stresses and changes of compression and tension due to rolling loads.

No one type is predominant, but the arch enters into most of them. An arch is not only a pleasing form of construction, it is based on sound scientific principles and is an economical disposition of material. I have considerable doubt whether it is desirable to construct hinged arches in this material, whether two-hinged or three-hinged. It appears to me that it is almost equivalent to using simply supported girders when you have the opportunity to make them continuous. There is, of course, the advantage that the line of thrust must pass through the hinges, but there is no difficulty in so proportioning an ordinary fixed arch that the line of thrust nowhere unduly leaves the thickness provided. It may be said that no one knows the exact course of the line of thrust, but we know that Nature takes the course of resisting a load with the minimum of stress, and we shall not be far wrong if we take the line of thrust so that the extreme stresses on the opposite haunches are as nearly equal as possible. The favourite method of construction seems to be a flat or cambered floor with cross and main beams and pillars from the main beams to the arch itself, the arch being a continuous sheet or ribbed sheet; when the latter the pillars are braced transversely and the arch is stiffened by a repetition of main and cross beams similar to those under the bridge floor. In this work, as in all arches, it is necessary to provide rigid abutments, but reinforced concrete will withstand a shifting abutment better than any other material.

The progress made in arched bridge-building in reinforced concrete is remarkable for a comparatively new material. Among the larger examples we have 233-ft. span in the Walnut Lane Bridge, Philadelphia; 320 ft. at Grafton, New Zealand; 328 ft. over the Tiber at Rome; 330 ft. at Largweiz, in Switzerland—all within 100 ft. difference. Now we have the proposed Spuyten-Duyvil Creek Bridge at New York, where a span of 703 ft. is proposed, or more than double.

Highway Bridges.—The general movement that has taken place throughout the kingdom to improve the high roads has not gone so far as it might have done in the direction of improving the existing bridges. As reinforced concrete is such an admirable mode of construction for highway bridges, the Concrete Institute formed a joint committee with other bodies to standardise the loading to be provided for in bridges of different classes. They collected information from all parts of the country of the weight and dimensions of the actual traffic, and decided what maximum loads each class of bridge should be rated to carry. Their labours are nearly completed, and it is hoped that they will be able to produce a single chart that will reduce the draughtsman's labour to a minimum.

Steel.—Although steel, according to the late Sir William Siemens, has been used for structural purposes from the year of the Great Exhibition (1851), the modern use of steel framework in the construction of high buildings dates practically from 1881 in America and more recently in England. The extensive use of steel in all classes of buildings at the present time makes the study of steel-framed construction of the utmost importance; but it is a very great mistake to imagine that any member of this Institute wishes to put reinforced concrete in the background because of the importance of steelwork. Our Institute was built up on reinforced concrete, and it should be the primary care of the Council to see that it does not suffer by reason of any extension of the scope to other modes of construction.

But steel-framed buildings, although the chief branch of metalwork to interest us, is not the only one. We must know something of bridges in metal before we can properly make a comparison with those in reinforced concrete, and it is not the smaller ones only that we should study. A steel bridge now constructing in this country for erection across the Ganges is a mile long, in fifteen spans of about 350 ft. each, and will contain 30,000 tons of steel.

Reinforced Concrete Piles.—The Science Committee have for a long time past endeavoured to gather useful information upon the driving and supporting power of reinforced concrete piles, but so far they have not been able to collect sufficient material for a report. Records of the weight and fall of ram, number of blows, and distance driven are very numerous, but comparatively useless. Sometimes the records are accompanied by particulars of a test, when the pile sustained a given load without yielding, but whether it would have yielded with ten or twenty times the test load we have no means of knowing. What is required is a series of experiments with small piles, say 10 in. square, 20 ft. long, driven 15 ft., and then loaded until they sink farther. This would do for a beginning and would enable us to compare reinforced concrete piles with timber piles. I have a collection of about forty formulæ for the latter kind, all more or less *unreliable*, but none at all for the former. At Halifax, Nova Scotia, the largest reinforced concrete piles have been recently driven by the largest pile-driver in the world. The piles were 2 ft. square and 77 ft. long; the hammer, follower, and follower-guide weighed 28,000 lb., and the ram alone weighed 4,000 lb. With a mean effective steam pressure of 80 lb. per sq. in. in the cylinder of the engine operating the driver the hammer is rated to develop 3,916,000 ft.-lb. per minute when striking eighty blows per minute. Twenty-five piles have been driven by this machine in a ten-hour day. But this record is already exceeded by some piles at Havana, and tenders have been called for a pier at San Francisco in which piles of 91 ft. long and 20 in. square are required to be constructed. They will weigh 15 tons each and are specified to carry in addition to their own weight a load of 40 tons. The concrete will be 1 : 2½ : 5, and will be allowed forty-five days for setting before being driven.

Foundations.—Reinforced concrete has been the means of saving a considerable expenditure of money in the cost of foundations otherwise than by piling. By enabling the pressure to be spread over a considerable area, without much doubt it has in many cases enabled buildings to be safely erected upon soil that would have defied the old method of putting in foundations. Concrete rafts have been used for a long time, but until they were reinforced it was not uncommon to find the heavily loaded parts punching their way through the concrete. Perhaps the greatest innovation is possible in connection with bridge foundations, which are often very deep, 100 ft. or more below high-water mark. In the case of the Hawkesbury Bridge, in New South Wales, the foundations went down to 162 ft. below high-water level.

VOTE OF THANKS.

Mr. E. P. Wells, J.P. (Past President, Concrete Institute), in proposing a vote of thanks to the President for his address, said Professor Adams had called attention to the formulæ for the calculation of bending moments in reinforced concrete. He agreed, as he thought they all did, that it had been rather an unwise and mistaken policy to alter these formulæ. They ought to have remained as they were generally accepted in all methods of engineering, and not have been changed purely because it was reinforced concrete that was being dealt with. There was no doubt they all learned by making mistakes, and those who had had failures should come publicly forward and state them and explain the causes that had led up to them.

It was not always the engineer or the architect who was responsible for them, and personally he did not agree that it did the contractor a serious amount of injury if a work had failed.

The cost of breaking up reinforced concrete work was three or four times as much as the cost of putting it into position, and it was difficult to know how to demolish reinforced concrete structures. The employment of explosives, of course, was out of the question altogether.

It was a very great pity that the Local Government Board could not see their way to grant a further extension of time for the payment of loans. That had been a great deterrent, and local bodies especially would not put up reinforced concrete buildings when the loans had to be paid off in such a short time.

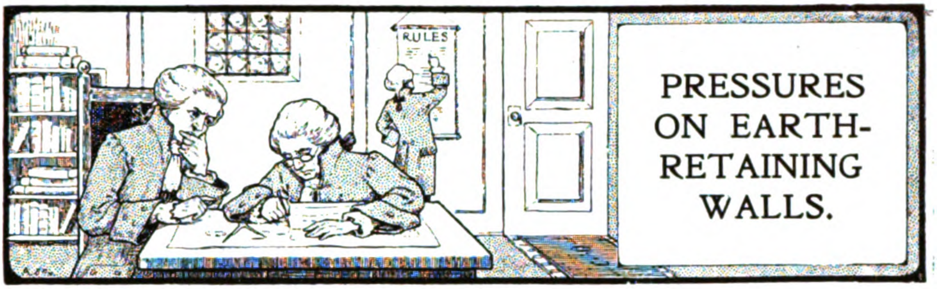
Sir Henry Tanner, I.S.O. (late Principal Architect, H.M. Office of Works), seconded the motion, and observed that he could see no reason whatever why reinforced concrete should not be dealt with in the same way as any other part of building construction—that was: making a proper specification, getting quantities in the usual way, and obtaining tenders. The present system by which there were half a dozen different designs and perhaps twenty tenders led to all sorts of confusion and trouble. When they had a standard specification and a definite set of Regulations in London it would be more easy to follow the usual plan of getting tenders for reinforced concrete. If the Local Government Board made Regulations for London, in the course of time they would be extended to the rest of the country, and if public authorities knew at the outset that they could obtain loans for ten, twenty, or thirty years they would be more likely to avail themselves of the advantages of reinforced concrete work.

The unfortunate case of the Western District Post Office had been referred to, and although he had no direct interest in it, he could say that it was the result of a very stupid mistake. On the other hand, he could not understand why any builder should wish to take advantage of anything of that kind and endeavour to enforce it in a Court of Law, as the result made him look rather foolish.

He had had a little experience in pulling down reinforced concrete under the old building of the Engineers, in Great George Street, but the trouble they had in getting it apart was to a large extent due to the fact that about twice as much concrete had been used than there was any need for.

Mr. E. Flander Etchells, P.Phys.Soc., in supporting the resolution, said he agreed that bad workmanship should be provided for and guarded against, but whether in the bending moment or in the matter of stresses could not be discussed that evening. In regulations it might be necessary to provide for something more than the laws of mechanics; it might be necessary to give consideration to the laws of finance, counting the cost, and it might also be necessary to take into account the laws of human nature.

The President, in acknowledging the compliment, referred to the points raised by the various speakers, and the proceedings then terminated.



PRESSURES ON EARTH-RETAINING WALLS.

The following Diagrams and Notes on Pressures on Earth-Retaining Walls are probably of interest to many of our readers.—ED.

THE pressure of earth upon retaining walls with varying angle of surcharge can be found readily by means of the accompanying diagram, *Fig.* 1. The values obtained are those given by the " wedge " theory, which is very generally used as a test of the stability of such walls.

Curves have been drawn for angles of repose (ϕ) of 30° and 45°. In view of the necessary incompleteness of any theory of earth pressure, it appears to be

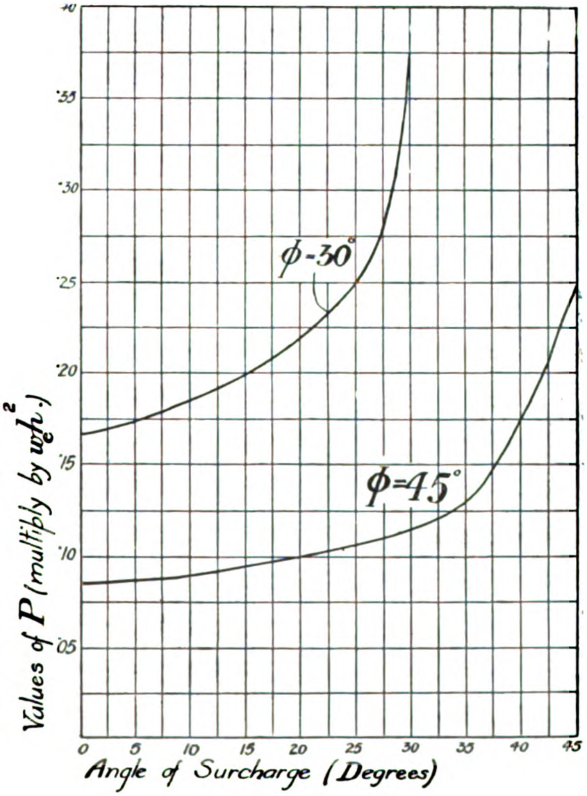


FIG. 1.

sufficiently accurate to take one or other of these angles according to the nature of the soil. For any given angle of surcharge (θ), say 15°, we read off the value given by the diagram for the given angle of repose—say 30°; in this case this comes to ·20. We then multiply this by $w_e h^2$, where h^2 is the height in feet of the wall (say 10 ft.) and w_e is the weight per cubic foot of the earth (say 120 lb.). The result (2,400 lb.) is the pressure P of the earth against the wall per foot length of the latter; this acts horizontally at a depth $\frac{h}{3}$ from the base.

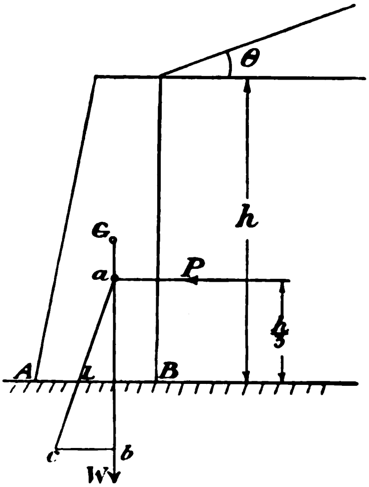


FIG. 2.

To complete the investigation as to the stability, the pressure P is produced to meet at a (*Fig.* 2) the vertical through the centre of gravity G of the wall section, and ab is set down to scale to represent the weight W of a foot length of the wall, and bc is set out horizontally to represent the pressure P to the same scale. Join ac cutting the base AB of the wall in the load point L. Then for stability AL must not be less than $\frac{AB}{3}$.

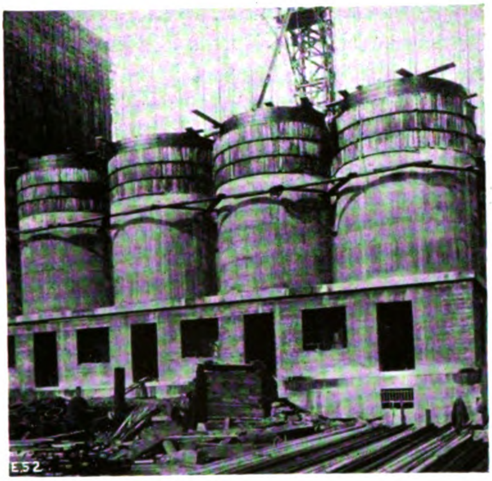


FIG. 1. FORMS FOR GRAIN SILOS.

COLLAPSIBLE STEEL CENTERING.

We present herewith some illustrations and particulars dealing with collapsible steel centering which will doubtless be of interest to many engineers.—ED.

AT the present time owing to the very heavy increase in the cost of suitable timber for constructing forms, many engineers will be considering what substitute may be employed, and their attention will naturally be drawn to some system of steel forms. A brief description, therefore, of various steel forms at present in use may not be without interest, and the accompanying illustrations show various types. Where there is a repetition of work the steel form possesses many advantages over timber owing to the fact that its life is practically unlimited, and cannot be cut or damaged in the

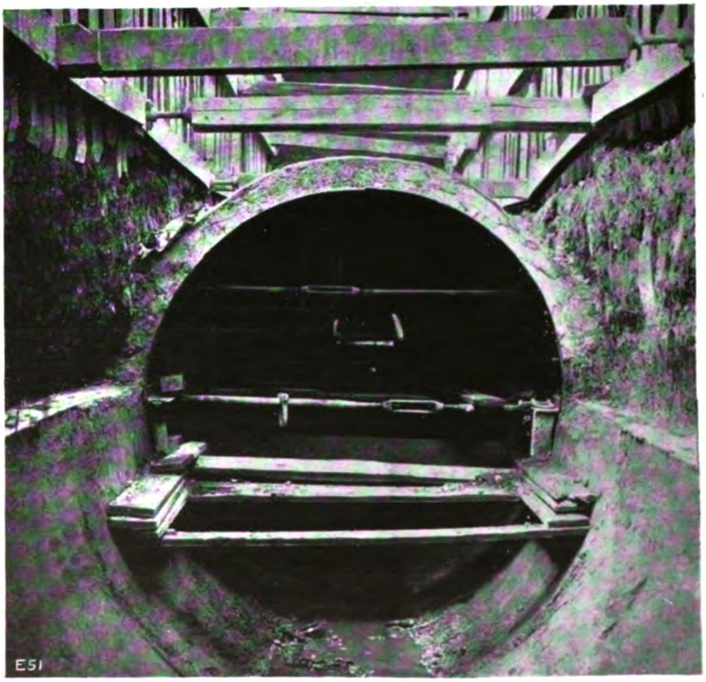


FIG. 2. SHOWING A FORM OF HALF-ROUND CENTRE.

course of use. Further, it ensures uniformity of construction, and being non-absorbent it is claimed a very much finer finish is obtained to the concrete.

Up to the present the principal use for these steel forms has been found for the construction of sewers, conduits, etc., where the steel form may be used a very large number of times without being damaged in any way. There are many shapes and types of form employed, all depending on the nature of the work to be carried out. Frequently half-round forms can be employed for constructing the invert first, and then reversing them and constructing the crown, whilst on other occasions full round forms must be used, so that the sewer may be completed at one operation. In this case it is often necessary to employ telescopic forms so that they may be worked forward from the rear to the front, and a type of this form is shown in *Fig.* 3.

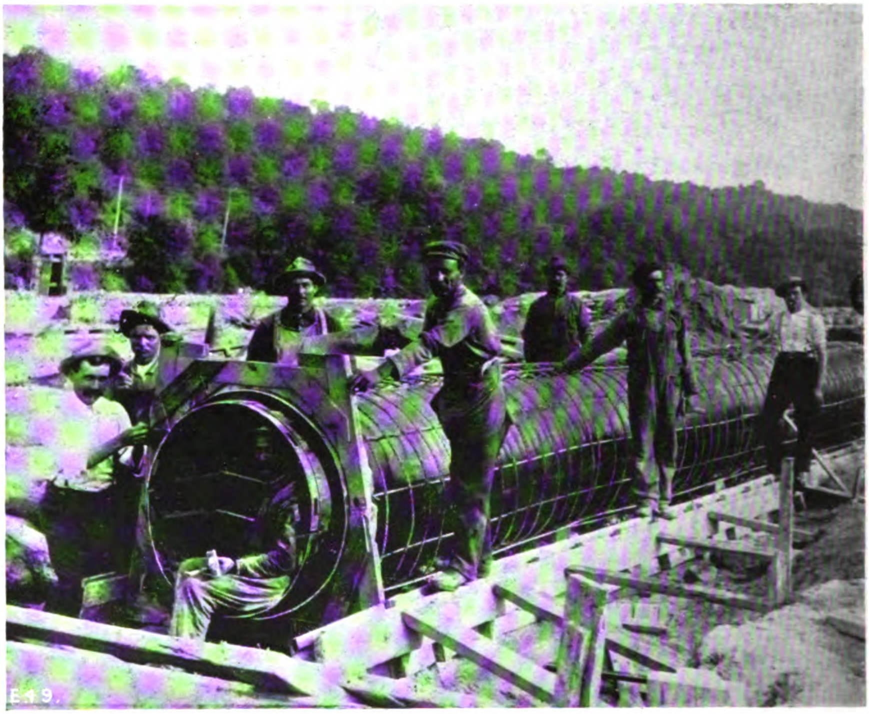


FIG. 3. VIEW OF TELESCOPIC FORM OF CENTERING.

Fig. 2 shows a form of half-round centre. In conduits or tunnels of large size where a heavy form is employed, it is necessary to use a carrier to transport the forms to the next section. This consists of a light steel trolley with adjustable screws, which draw the centre gently away from the concrete and then lower it so that it may telescope through the centres in front for the next work. It is often necessary, in constructing tunnels, to use laggings in place of a complete centre, owing to the difficulty in placing the concrete, and these consist of circular rings to which the lagging plates are attached, a fresh lagging being put on as the concrete is brought up to the level, and finally the key lagging is put in and the concrete rammed back from the front. This operation is continuous, the rear laggings being carried forward to the next section.

Fig. 4 shows adjustable jack arch forms for subway construction, from which it will be seen that a large number of centres are used at one time, thus ensuring perfect size in section.

In the case of wall forms each job has to be treated on its own particular merits. Where the wall is reinforced it is necessary to use a series of laggings to ensure proper ramming of the concrete, whilst if it is a mass concrete wall the centres may be all assembled and transported on a carrier, thus ensuring the minimum amount of cost in fixing the forms. Side walk and curb forms are also made so that the curb, gutter and footpath, are all constructed at one operation. For columns uniformity of size is necessary, so that the steel form can be employed also for arches, tanks, silos, bridge piers, etc.

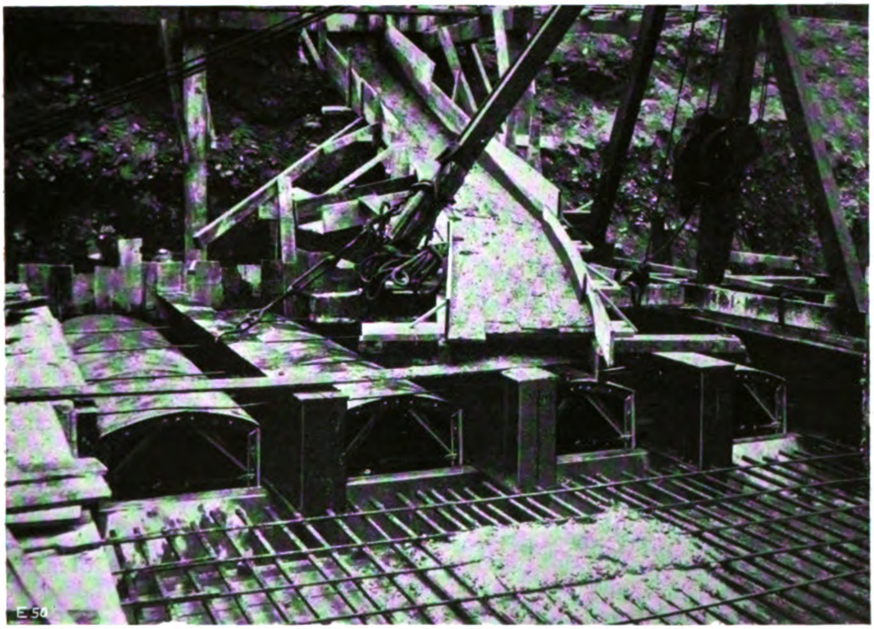


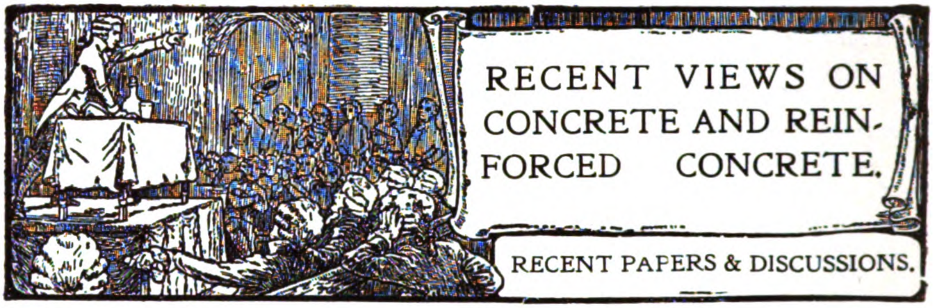
FIG. 4. ADJUSTABLE JACK ARCH FORM FOR SUBWAY CONSTRUCTION.

The illustration at the top of this article shows these forms in use on the construction of grain silos.

For floors, steel forms can also be used, provided the spaces between the beams of the various storeys are uniform or can be made up with multiples of the various size laggings.

Many large and important works have been carried out with steel forms, such as the culverts on the locks on the Panama Canal; the Catskill Aqueduct for the water supply of New York; the Cairo Drainage Works, and Collectors at Woolwich, and sewers at Bedford and Blyth, and many other parts of the world.

The system here illustrated is the "Blaw" Patent Collapsible Steel Centering, the patents of which are operated in Great Britain and the Colonies by the British Steel Piling Co., of Dock House, Billiter Street, London, E.C., to whom we are indebted for the photographs.


RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.
RECENT PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

AMERICAN SOCIETY FOR TESTING MATERIALS.

EXAMINATION OF CONCRETE FAILURES FOR THEIR DETERMINING CAUSES.

By R. S. GREENMAN.

The following Paper was read at a recent meeting of the American Society for Testing Materials:—

CONCRETE is said to be its own best inspector, and it is a well-known fact that defects in concrete will sooner or later make their presence known.

For every fault there must be a reason. The reasons for poor concrete have been proportioned as being 90 per cent. due to poor workmanship, 8 per cent. due to poor aggregates, and 2 per cent. to poor cement. These percentages are not the result of tabulations, but are those prevailing in the minds of many who have had considerable opportunity for inspection of concrete, both good and bad. But whether or not these percentages are correct, the statement raises the question, "What are the reasons for poor concrete, and how do we determine these reasons?" It is a certainty that neither a laboratory test nor a field inspection alone will give them, unless, of course, it be a simple failure. Yet there are people who will examine a piece of concrete in the laboratory and offer a solution of the problem simply by tests made there. And again, an inspector will look over a piece of concrete construction, and with no knowledge whatever of the characteristics of the materials used, nor of the method of making, will attempt to tell how such and such a condition developed. Concrete failures can only be explained after thorough investigation by men who know good or bad concrete from long and close acquaintance, and whose minds are of an analytical and judicial temperament.

The more one sees of concrete the more one becomes convinced that it is the most abused structural material being used. The science of making concrete has been looked upon too generally as being very easily learned, with the natural result that a great deal of poor concrete has been made. Now, however, builders, contractors, and engineers apparently desire to make concrete that will meet the standard in quality required of other materials, and yet, with all the precautions now being taken, there is still a large amount of concrete that is not satisfactory. The larger the work the greater the care taken; and, vice versa, the smaller the work the greater the carelessness and the greater is the ratio of the failures, and it is the sum total of these failures that makes the loss caused by poor concrete so great.

In trying to solve a problem of poor concrete the elements to be investigated are the three already mentioned—cement, aggregates, and workmanship—and water. The common tendency is first to place the blame upon the cement, but if we find that in accordance with good and generally common practice, the cement has been tested and has met the standard requirements, the cement then becomes a negligible factor;

but if it has not been tested, it must be considered as a possible cause, and it may become a large item in the study. We must admit that since so much stress has been laid upon the value of having cement tested before use, and since it must indeed be a small work where it has not been so tested, the percentage of failures due to poor cement has been reduced to a very small amount.

If the next element has been given equally as thoughtful consideration previous to its use, there could not be so much poor concrete due to poor aggregates. The strong and weak points in both the coarse and fine aggregates have been too often neglected. The coarse aggregates can usually be judged by easy inspections, but sand or other fine aggregates need very careful examination. Its characteristics—such as the grain, the grading, the cleanness, and its freedom from organic impurities and excess of loam—are items of knowledge which are obtainable mainly in the laboratory, but which are very essential for the correct diagnosis of a concrete failure.

The effect of workmanship is by far the largest factor, and in it all others are included, for a poor workman can destroy the value of the best materials. Under the head of workmanship must be considered such items as design, proportions, placing, and actions resulting from heat, frost, electrolysis, etc., which should have been taken care of during the process of making, hardening, and preservation.

As another element of importance, it must always be kept in mind that the water used in making the concrete, or which may come in contact with it, may prove to be a very influential factor for harmful results.

Then, if one is given a concrete failure to diagnose one must look for a reason under cement, aggregate, workmanship, and water. As stated, the easiest explanation is to look for some fault in the cement, but if, as has been suggested, the cement had passed the usual tests, then other reasons must be found. To find them requires that the investigator shall first know conditions and causes of failures, but these will not be further discussed except to point out the way to the reason; then the investigator must attack the problem with an open mind—that is, he must not jump at a conclusion and expect to be able to work out an explanation around that conclusion. Then it is even more essential that the investigator shall have had an opportunity to learn of results of tests, or to make tests that will enable him to judge the probable actions from the characteristics of the aggregates. Also, a very careful examination of the concrete in place is generally an absolute necessity.

To attempt to outline a plan for procedure in this examination would be folly, since each individual case has conditions that are decidedly its own, and the law of probabilities makes possible many combinations of causes which can only be worked out as one would solve any involved research problem. Clues must be sought, and a sharp eye, a quick ear, and a questioning tongue must be alert to grasp a clue and pursue it to a definite ending. If any one should be sceptical of the efficiency of this method, it is possible that a few illustrative cases, selected from a large number of diagnoses, may convince one that the method has proven and can prove successful far more than is generally accepted.

Illustrative Cases of Failure.

Failure due to Water.—A highway was being built and the plans called for several new concrete culverts. All but one of these culverts "set up," or hardened, nicely. This one did not, and yet the same cement, sand, and stone had been used as in all the other culverts. A reason for the failure of the one culvert was desired.

It was found that the brook which flowed through this particular culvert passed in its course the plant of a company engaged in the manufacture of medicine from herbs. The refuse from the plant so loaded the water with organic matter that it prevented a proper hardening of the concrete. No one connected with the construction of the culvert knew that water so contaminated would have that effect, and the complaint came in that the cement was not acting properly. The brook was temporarily diverted, other water was used, and the concrete acted normally. A condition had existed there which would not have existed in city water, but which is found frequently in the country, especially in wooded sections. To detect the cause one had to know that certain elements, such as tannic acid, alkali salts, etc., foreign to most waters, do affect concrete.

Failure due to Sand.—For an illustration of the effect of a poor quality of sand, consider the following case:—

A cry of alarm came in from an engineer that the concrete in an important bridge abutment had been in place for over two weeks, and that in attempting to remove the forms it was found that the concrete was still so soft that it could be cut out with a knife. A brand of cement new to the work had been used, and the blame was of course placed on it. An examination showed that a footing for the abutment had been made of the brand of cement first used on the work, and that, although ten days older, the concrete could easily be cut with a knife. The evidence eliminated the cement.

Examination of the sand showed it to be a well-graded, sharp sand, but a clue was furnished by some yellow-coated grains. The investigator had already had considerable experience with similar sand grains. A trip to the sand bank showed just what he expected to find. The bank had not been stripped of a top layer of yellow-coated sand, which gives a sand with which it is mixed a tendency to very materially delay the hardening of the concrete in which it is used. In time, usually several months, the concrete will harden, and there is ultimately no harmful effect apparent. Lack of knowledge of this peculiar quality had caused an investigator of another piece of work to tear it out and rebuild.

Failure due to Stone.—A very unusual condition existed in another case, but it emphasises strongly the need of following clues. A concrete wall was apparently disintegrating, due, as the engineers believed, to free lime in the cement. In various places on the face of this wall there appeared what can best be described as "blisters." By prising off these blisters there were produced small cones about 6 in. in diameter and 3 in. in height, and in the apex of each could be seen a small, yellowish-white spot about the size of a small marble. The trouble was clearly not a case of free lime in the cement. One unusually large blister enabled the author to dig out from the apex a soft stone about 1½ in. in size. This stone did indicate the presence of free lime, and after a few weeks on the author's desk slaked into a powder. Examination of the stone composing the coarse aggregate soon brought out the following:—

The crushed stone all came from the same quarry, but some came by a steam railroad and some by an electric railway. No concrete made by the former showed blisters. Concrete made from stone delivered by trolley did, but why? It seems that in the course of transportation by the trolley route, the stone was conveyed in waste dump-cars, across the grounds of the company owning the quarry and conducting a plant in which limestone is an essential raw material. These dump-cars had not been cleaned carefully, and to the good stone were added some small quantities of stone that had been through a chemical process and were on the verge of disintegration. In the concrete their expansive force blistered the face. By forbidding further deliveries by trolley the trouble was stopped.

These may be considered extraordinary cases, but it is the out-of-the-ordinary that makes trouble; if they were not the extraordinary they would probably have been guarded against. They are, at least, typical of points for which one must look if one would explain failures in concrete.

Failure due to Workmanship.—Failures due to poor workmanship are seen so often that instead of citing particular cases it will be sufficient to briefly note some causes or results.

Failures from faulty design are shown in the mode of failure. The lack of proper proportioning may be clearly seen in a fractured surface; the grading of the aggregates is also similarly noted; and poor mixing and improperly placed concrete readily show themselves. All these are evident to an eye trained to know good or bad concrete. The failure to take care of laitance is made apparent by the seams that are bound to result from such a failure.

A concrete may be dense but not sound and hard, and "sounding" with a hammer will show up this characteristic. Too wet a mixture with fine sand or silt, or a crusher dust used as fine aggregate, may be a cause. It may be sound and hard, and yet may be poor for certain uses because it is too porous. By scratching the face of unbroken concrete with a dull instrument one may sometimes judge of proportions used and, in its early stage, can also judge somewhat as to the rate of hardening. A pocket glass in the field and a microscope in the laboratory help materially in determining the density, and in approximating the ratio of cement and fine aggregate to the coarse aggregates. The naked eye is all that is needed to observe concrete spoiled by sweepings of sawdust, shavings, or blocks, or by waste carelessly dropped into a form. Lack of protection to fresh concrete from the sun or unusual heat may be noted by a "dried-out" and rapidly dusting surface, and from frost by a flaked and scaly surface.

INFLUENCE OF EXTERNAL FORCES.

Where concrete has apparently been good for a considerable period and has then begun to disintegrate, the reason for the failure must be sought in the character of the disintegration, whether it may be due to changes in the elements making up the concrete or to some external elements or forces that have entered into it. If due to an internal influence alone, the fact will be noticed by the granular breaking up of the concrete. If due to an external force, such forces as sea water, alkali salts, or electrolysis will be under suspicion as being responsible if the concrete has been under the influence of any of them. For many years all the failures of concrete were considered as being due to the formation of certain chemical relations; but as it is commonly acknowledged at present that an impermeable concrete will stand in sea water as well as elsewhere, although subjected frequently to more severe actions than other concrete, its failures are due frequently to the same causes as those of other concrete, and therefore the same examinations should give the same results. Similarly, since electrolysis is considered as a cause for the breaking down of concrete, the liability of concrete being affected by its influence will depend upon whether the concrete comes under the influence of an electric current. If it does, then its influence needs to be examined. If it does not, then the examination should also follow the usual method.

CONCLUSIONS.

The value of laboratory tests and analyses should not be overlooked. While perhaps not giving as definite information as a field inspection, they should be used to the fullest extent to help establish the strength or weakness of a reasonable theory for the cause of failure. Where time will permit, laboratory tests of concrete made of the aggregates under as nearly as possible the same conditions, will give results that should aid in determining the fault in the original. Test specimens so made and treated should give practically the same results, and when compared with test specimens made under ideal conditions or with standard materials, should give the investigator the reasons for the failure.

All means possible should be used by an investigator in making his examination, and his conclusions must be drawn only after he has considered the failure from every probable cause with reason and fairness. The object of the examination is either to place responsibility or to guard against future failures, and right conclusions are the only ones that should be drawn if justice to either objective is to be given.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

CONCRETE DAM ON THE MISSISSIPPI RIVER, COON RAPIDS HYDRO-ELECTRIC PLANT.

THE accompanying illustration and drawing show the concrete dam of the Coon Rapids hydro-electric plant on the Mississippi River, six miles above Minneapolis. It is stated that 15,000 h.p. will be developed with only 17½ ft. head. The dam is supported on piles with steel sheet-pile cut-off walls beneath, and the water level is regulated by large Taintor gates on the dam crest. There are vertical turbines used of 2,100 h.p., carried on roller bearings at the top of the shaft. Steel-framed forms were used for the dam.

It is said, in reference to this hydro-electric power plant now under construction at Coon Rapids, that there is no storage capacity, but at low stages of the river the flow will be sufficient to develop only about 4,400 h.p.

It is pointed out that this great variation in power capacity would not be satisfactory for an independent plant, but this plant will be an auxiliary to the larger hydro-electric plant, of 25,000 h.p., at Taylor's Falls, on the St. Croix River, supplying current for lighting, traction and general power purposes in both Minneapolis and St. Paul.

There is a steam plant of 16,000 h.p. held in reserve at Minneapolis, to take care of peak loads, and the Coon Rapids plant will provide for these loads and will enable the steam plant to be shut down, and kept as a reserve for use only when the river is low or in case of any failure at the water-power plant.

It may be mentioned that there is an island in the river at the side of the dam, and as the left channel is narrower and deeper than the others, it was decided to place the power house across this channel, and to build a spillway dam across the wider and shallower channel, the water level being regulated by a row of Taintor gates along the top of the dam, raising the normal water level 7½ ft. above the spillway level.

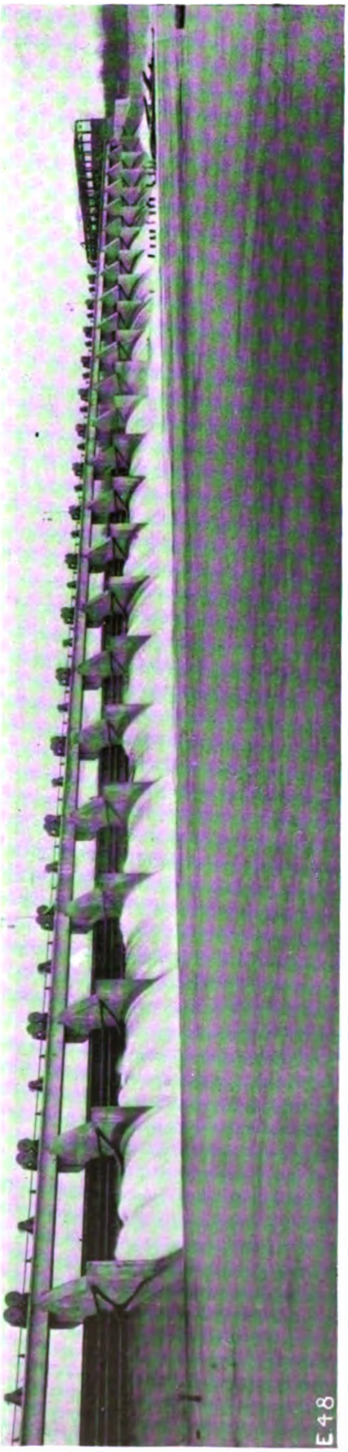
This arrangement is similar to that at the Keokuk Dam, but in the latter case vertically sliding gates are used. The spillway has a discharge capacity of 80,000 cu. ft. per sec. A concrete retaining-dam extends across the head of the island from the end of the spillway dam, and between this and the power house are located a fishway, a log chute and four sluice gates.

An earth embankment extends from the power house to the high ground on the north bank. With this arrangement of the power house and spillway no flood water will be passed through the tail race, and the effective head will be reduced during flood stage only by the backwater from the foot of the island. The spillway dam has a length of about 1,000 ft.; the retaining dam at the head of the island, 170 ft.; the sluices, log chute and fishway, 62 ft.; the power house, 255 ft.; and the embankment, 570 ft., making a total length of 2,070 ft.

It is of interest to note that the main dam is built on a deep bed of glacial drift. The Great Northern Development Co., in its preliminary work, has made a line of wash borings across the river, approximately on the line of the dam, and other borings above and below the line. These indicated that rock was at too great a depth to be reached by the foundations.

It may be stated that the spillway dam has a base width of 27 ft. 9 in., and a height of about 12 ft. to the spillway crest. Within it is formed a drainage conduit, with openings in the bottom to a gravel-filled trench or filter, so that any water working beneath the heel can escape without causing upward pressure on the base of the dam.

Below the dam is a reinforced concrete apron, 50 ft. wide, to prevent scour at the

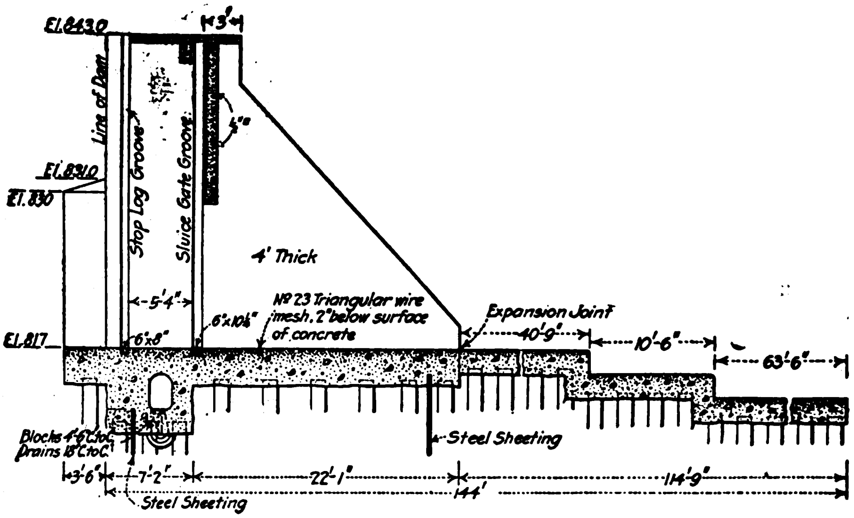


View of Concrete Dam.
Mississippi River, Coon Rapids Hydro-Electric Plant.

toe. Along the dam are piers 3 ft. thick and 36 ft. apart, carrying two lines of reinforced concrete girders, with a deck 8 ft. 3 in. wide, on which are mounted the hoists for operating the Taintor gates. The boxes for the shafts of these gates are carried in the rear end of the piers. This concrete dam is carried on foundation piles, driven to varying depths, and until the penetration indicated a safe bearing value of ten tons per pile.

In order to provide a cut-off against flow of water beneath the dam there are two lines of steel piling, driven to penetrate at least 5 ft. into material which, from the borings, was assumed to be impervious and which varied in depth below the river bed from about 2 ft. at the south end of the dam to about 25 ft. at other points. A third row is carried under the toe of the apron, but this is only 8 ft. deep, being intended to prevent scour beneath the apron by back-wash. For about 200 ft. at the south end, where compact material rises to the surface, a trench was cut in this and a concrete cut-off wall built.

The power house also has pile foundations, driven to refusal in the compact material, while lines of steel sheeting form the cut-off. In the forebay is the wall of the intake, with submerged openings to the screen chamber, which contains the inclined trash racks and has grooves for Stoney gates to close the inlets to the turbines when necessary. The gates will be operated from a hoist on a gantry crane spanning the chamber, one end of the crane-girder having wheels riding on an elevated runway along the wall of the power house, while the other end rests on a leaf with wheels riding on a rail laid along the forebay wall. From the inlet the water enters the scroll chamber, and after passing through the turbine is discharged through the draught-tube,

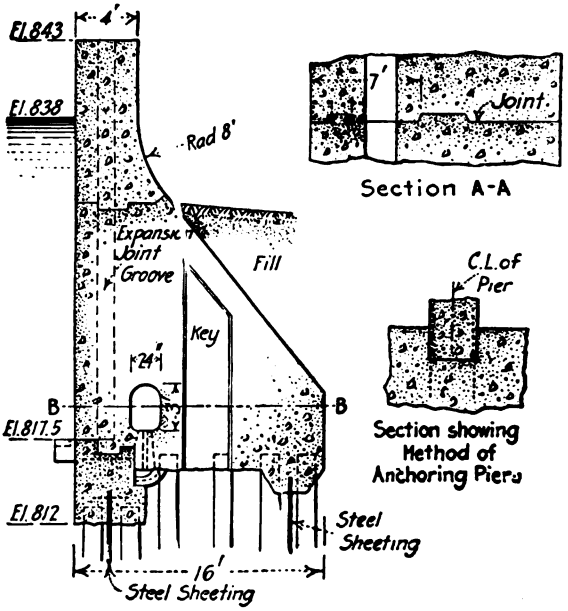


Section through Sluice Gates.
Mississippi River, Coon Rapids Hydro-Electric Plant.

which enlarges from a circular opening 12 ft. 6 in. diameter beneath the turbine to an oval opening 32 ft. by 33 ft. in the rear wall.

This discharges the water into the tail race, which has an inclined floor of concrete on a slope of 1 in 4, rising from elev. 795 to elev. 813, which is the level of the river bed. There will be seven vertical-shaft turbines of 2,100 h.p. each, five of which are to be installed at present. The shafts are suspended from roller bearings above the generators. The twenty-eight Taintor gates along the top of the spillway dam are 32 ft. 11 in. long on the face, and 7 ft. 6 in. high, with a face radius of 10 ft. 6 in.

It is of interest to note that heavy vertical girders are connected by L-beams, to which the face-plates are riveted, and the construction is sufficiently stiff to enable cross-bracing to be eliminated. Each gate weighs about 6½ tons, and is operated by a pair of chains passing over drums mounted on the concrete deck or bridge and arranged for either hand or motor operation. When closed, the edge of the gate rests on an oak sill on the crest of the dam, and as such sills invari-



Cross Section of Retaining Wall
Mississippi River, Coon Rapids Hydro-Electric Plant.

ably warp to some extent, a water-tight joint is made by a doubled strip of rubber belting, which is attached to a timber on the face of the gate and projects below it so as to lie against the bevelled corner of the sill. The ½-in. clearance at each end of the gate is also sealed with a rubber strip riding against the face of the pier.

The Stoney gates for the intakes have a framing of 18 in. vertical and 15 in. horizontal I-beams, with ⅜-in. steel plating on the upstream side, while at each end is a train of rollers riding against a guide in the groove in the masonry. These gates are 15 ft. 2 in. wide (for 14½-ft. openings) and 17 ft. 9 in. high, weighing about 8 tons each. In the centre of each is a filler gate 24 in. by 21 in., having threaded lugs engaging with vertical operating screws.

On the top of each gate is a clevis loop, for the hook of the operating gantry crane. The four sluice gates are 6 ft. 5½ in. wide and 11 ft. 9 in. high, weighing about 1½ tons each. The Stoney gates and sluice-gates close against wood sills when lowered.

The sluice gate for the log chute is 10 ft. wide and 9 ft. high, but it moves downward instead of upward in opening. It is operated by a rack and pinion at each end, the shaft being driven by a worm gear and hand wheel. The embankment beyond at the north end of the power house has a concrete core wall, with a line of steel sheet piling beneath it.

The slope of the embankment on the water side is paved with sacks of concrete laid on 6 in. of broken stone or gravel. There is a considerable amount of logging on the river, and special means are taken to keep the logs away from the forebay and spillway and to guide them to the log chute for passing the dam. Along the north shore and extending across the forebay is a heavy timber boom attached to cribs and forming one side of the approach to the chute.

There is another floating boom extending from the opposite side of the chute in a diagonal line across the river. The sections of this boom are anchored by chains to pairs of piles having the heads cut off below the water line. The Great Northern Railway and Northern Pacific Railway are about a mile from the site, and within about half a mile are a public highway and the Minnesota and Northern Railway.

The trestle used in constructing the concrete dam carried three tracks, and on the side next to the dam was a standard-gauge track on which ran a locomotive crane for handling the form work, depositing concrete and setting Taintor gates. Between the rails was laid a third rail to form a track of 3-ft. gauge, and another track of 3-ft. gauge was laid on the upstream side of the trestle. On these two tracks operated the light locomotives and concrete cars, and the tracks were connected at frequent intervals by crossovers to facilitate operations.

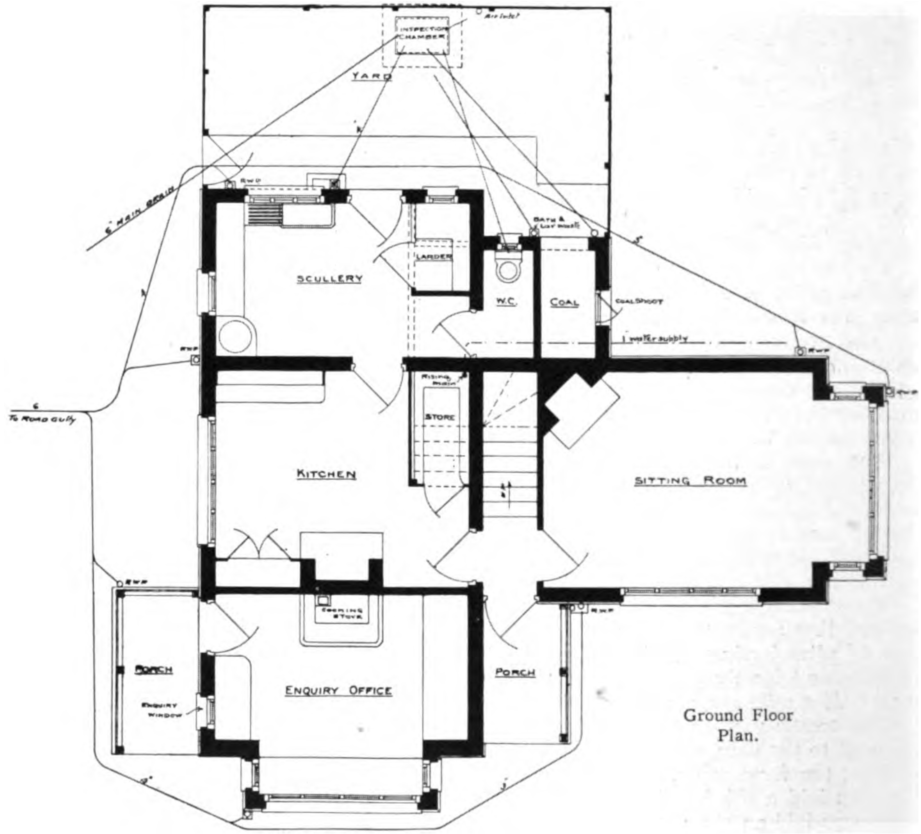
The trestle track was a little above the level of the top of the dam, and for the upper part of the work the concrete was delivered in dump buckets (on flat cars), which were hoisted by a locomotive crane and dumped into the forms. This crane was used also to handle the forms and other material. The concrete was mixed 1 : 2 : 4 for reinforced work, 1 : 3 : 5 for mass work, and 1 : 2 : 4 for the floor. All reinforcement was of square twisted bars. A good grade of sand was found adjacent to the work and the stone was crusher-run limestone.

The construction of the dam was done in two sections, enclosed within timber coffer-dams, consisting of a row of piles 8 ft. apart with walling timbers and a single line of triple-lap sheeting.

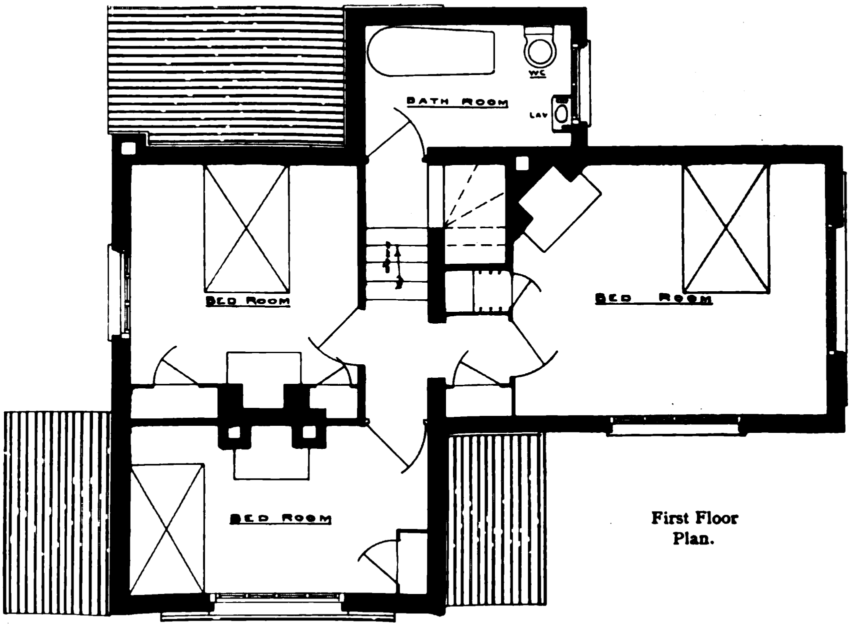
There was a bank of earth deposited against the outside of the sheeting to make it waterproof. For the power-house work, in the deeper channel of the river, the coffer-dam was of stone-filled cribs, held in place by piles. The deep excavations for the draft tubes extended some 25 ft. below the bed of the river. For the first four tubes the excavation was carried on while the sheeting was being driven and braced, and then the foundation piles were driven.

The vibration due to the pile driving, however, caused such pressure and movement of the material that the bracing was distorted and broken, and it was difficult to hold the sheeting in place.

On this account, for the other three draft tubes the steel sheeting was first driven, and then the foundation piles, these piles being put down to the required depth by means of followers. When all this was completed, the space to be excavated was enclosed by wood sheeting driven to the full depth, and the bracing was placed as the



Ground Floor Plan.



First Floor Plan.

CONCRETE LODGE AND ENQUIRY OFFICE.

excavation progressed. Forms with steel ribs were used for the whole of the dam, and these forms were in lengths of 54 ft. 8 in. The lagging was of wood, 4 in. thick, held to the ribs by light clamps.

In order to resist the upward pressure of the concrete deposited beneath the lagging, the forms were anchored by rods secured to the foundation piles. The upright posts of the forms were seated in pockets in a concrete shelf along the face of the toe-wall. The piers were built after the dam proper. Four 54-ft. openings in the spillway dam were left to provide ample waterway while the work was being done in the coffer-dam at the power-house.

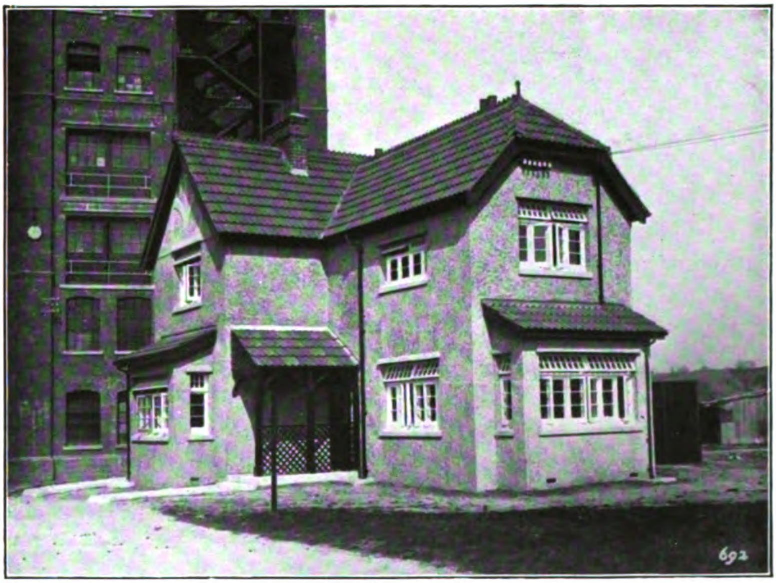
CONCRETE LODGE AND ENQUIRY OFFICE.

THE lodge here illustrated was designed for Messrs. Carsons, Ltd., Shortwood, Gloucestershire, by Messrs. Hal Williams and Co., London. It is situated immediately opposite the main entrance gates of the factory. The front room serves as an enquiry office and telephone exchange, and no person can enter or leave the factory without being seen from its windows. The kitchen, scullery and two bedrooms over are occupied by one of the employees, and the sitting-room and bedroom over is occupied by one of the assistant managers, who thus resides on the premises.

The main factory can be seen on the left of the photograph.

The lodge is built of concrete, covered with rough cast, and is roofed with double Roman tiles.

It cost, in round figures, £600. The contractors were The Building and Estates Development Co., Ltd., Bristol.

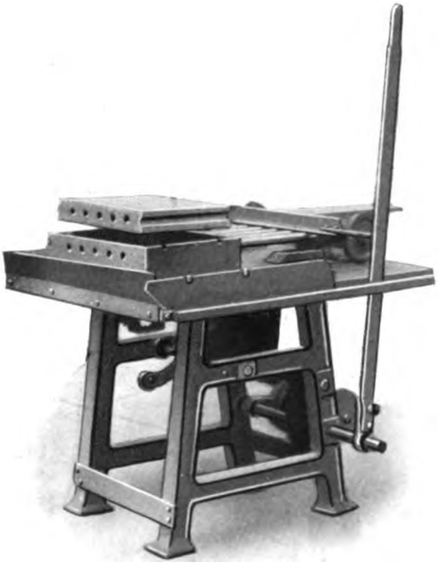


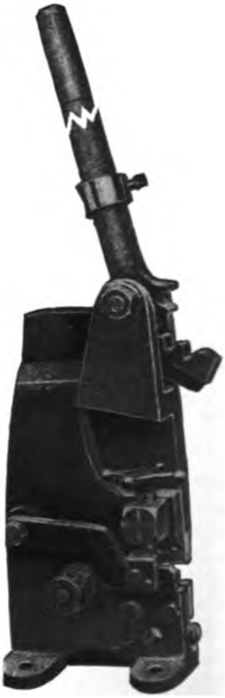
View of Finished Building.
CONCRETE LODGE AND ENQUIRY OFFICE.

INDUSTRIAL NOTES.

In continuation of the notes presented last month we now give a few particulars of accessory tools, appliances and moulds which are used in concrete and reinforced concrete work, also some tile and slab machines omitted last month.—ED.

R. H. Baumgarten.—This firm makes machines for concrete blocks, slabs, and tiles of every description for roofing, flooring, paving, mosaic work, pipes, as well as concrete mixers, etc. The illustration here shown is a slab machine for making hollow or solid slabs 18 in. by 12 in. or 27 in. by 16 in. The slabs can be made with straight ends and sides or grooved and tongued on two sides or all round. The agricultural pipes made on this machine range in size from 6 in. down to 1 in. in diameter and can be turned out five at a time. Mention should also be made of the roofing tile machine, which will make concrete interlocking roofing tiles in any colour and with side and head lock. Two hundred and fifty tiles can be made in a day, and the machine can be worked by unskilled labour. This firm also makes moulds of every description.



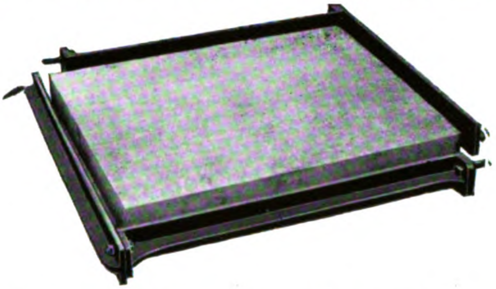


C. A. Hunton & Sons.—The accompanying illustration shows a *reinforced concrete rod shearing machine.* This machine will cut round or square iron of varying sizes, as will be seen from the diagram; the bars are fed in front and the entire cutting operation is within view of the worker. No change of blades is necessary for the various sections. The machine, as will be seen, is worked by a ratchet and lever.

This firm also makes a *handy shearing machine* for cutting sheet metal of any length or width. It will also cut flat iron or round and square metal. The bottom knife is adjustable and the various parts are interchangeable.

Mention should also be made of the "Handy" punching bear, for punching holes of varying diameter through iron plate. The advantages claimed for this machine are that it is light to carry and it punches parallel holes. All parts are interchangeable.

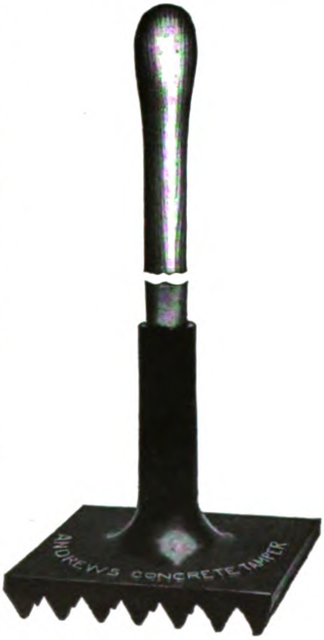
The (U.K.) Winget Concrete Machine Co.—The "Winget" improved rapid slab moulds are made of a special grade of cast iron. Two adjacent sides are connected rigidly at the angle, so that only two angles have to be joined up to complete the mould, ready for work. Thus, when the mould is to be stripped, only angles have to be released.



The fastening together of the two angles and their subsequent unfastening is a simple matter of two or three blows with a hammer, there being no nuts or wingnuts to operate or threaded bolts to rust or cement up and get out of order. The upper and lower edges of the moulds are parallel and are truly out of winding.

It will be seen from the illustration that the sides of the moulds are stiffened with a flange which makes them quite rigid in use and keeps them straight. These moulds are made in a large range of sizes and various thicknesses.

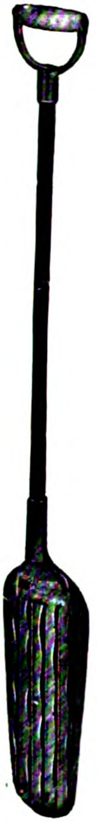
"Winget" Concrete Tamper.—According to the present practice, where a concrete floor or walk is required to have a smoothly finished top surface, the main body or layer of concrete is first laid with a mixture of stone or other aggregates, sand, cement, and water, in proper proportions, and when this foundation layer has partially or wholly set, spreading thereon a surface coating or layer of sand, cement, and water, richer in cement than the main body, which finished coating is smoothed off to give the required finish to the top or exposed surface. This procedure involves excessive cost, because of the larger percentage of cement required in the surface or finish coating, as compared with what is needed for strength and body alone in the first layer, and also because of the additional labour involved in making two batches of mixture and separately laying same.



The tamper illustrated is constructed so that the stones forming a part of the first layer of concrete are displaced, so as to cause sufficient sand, cement, and water to come to the surface to permit of the necessary smoothing of the layer giving the required finish at the surface, without the necessity of applying a special layer, requiring additional cement for that purpose alone.

It is 8 in. square, divided on its face with pyramidal projections, as shown in the accompanying illustration. These projections are connected at their bases in such a way as to prevent particles of stone from becoming wedged between them. For use, after the layer of concrete has been spread and roughly levelled with the customary straight edge, the workman proceeds to tamp, with the result that the freer sand, cement, and water come to the surface, leaving the latter in such a condition that it may be smoothed off with a float or trowel, substantially as the separately applied finish layer is smoothed off or finished.

The advantages claimed for this tamper are: (1) the obtaining of a homogeneous mass not liable to separation between any two horizontal planes, as in the case of two separate layers, being placed at different times; (2) it is possible to finish floor work at the time the base is laid, without running two mixing gangs and applying an additional surface finish, which is liable to separation at the base.



The Ross Concrete Spade relates to improvements in apparatus for moulding concrete. More particularly it is intended for use when an abutment or other structure is being built of concrete in which broken stone or screened gravel is to be employed in the main body of the structure, but which is to have a smooth facing, such as is formed by a more liquid mixture, composed of sand mixed with the cement without stone. In such work it has heretofore been customary to deposit the concrete mixture containing stone within the form and afterwards to insert a common shovel or spade between the face of the form and the mixture thus deposited and to press it back from the form, at the same time supplying a liquid grouting which runs into the space thus made and solidifies in contact with the face of the form, thus leaving a smooth, finished surface, without stone projecting to the surface. The manipulation of the tool in this manner is rather laborious, the results are uneven, and the process slow.

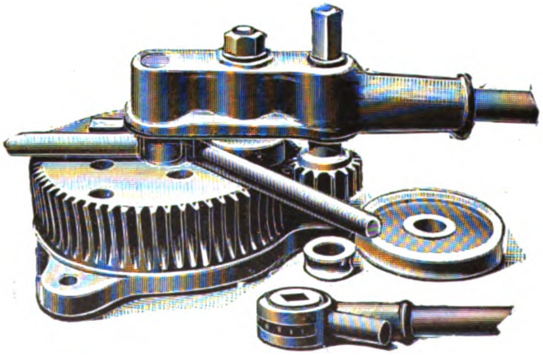
The spade here shown enables the work to be done more easily, with less expenditure of strength, more rapidly, more accurately and completely, and at a reduced labour cost.

The blade is designed to force the stone back from the form, leaving a space which is instantly filled by the freer cement, sand, and water, producing a white, clear, smooth surface.

The stones that are forced away from the face of the form are prevented from returning to the surface by the aid of the semi-plastic condition of the mass. The height of the projections on the blades of the spade is sufficient to give a suitable thickness to the smooth surface for all requirements. The long slope of the cam projections enables the implement to be inserted easily, requiring but little power to push the stones away from the form face, and it is also but little likely to disturb them in withdrawing the blade. The frequency of spaces between the projections permits the flow of grouting without causing suction upon the removal of the implement.

It is intended particularly for all vertical concrete structures, such as walls, piers, abutments, and all other exposed surfaces.

It is light, strong, and easily handled. The blade is of malleable iron, and the handle is of steel pipe.

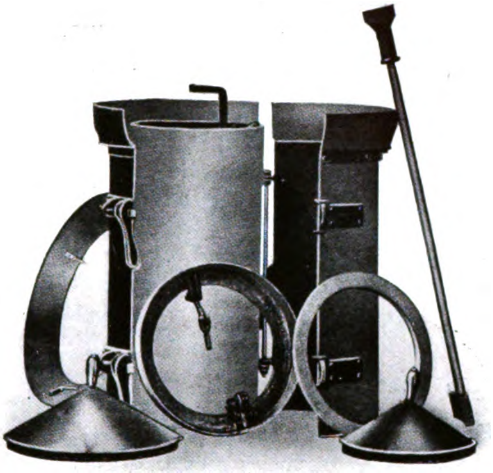


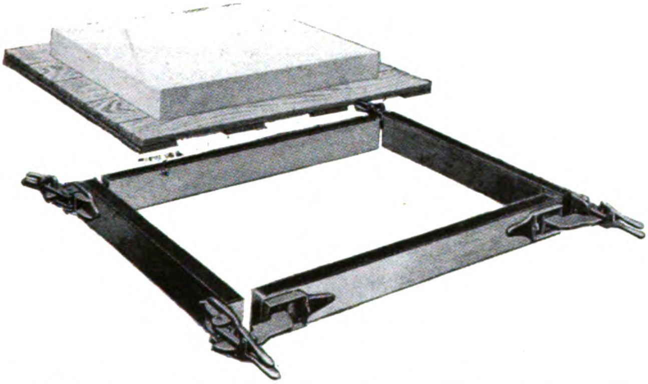
W. Kennedy.—Our illustration shows a patent bending machine (geared). This machine will bend bars up to $\frac{7}{8}$ to a radius of $\frac{3}{4}$ in. with lever only. It can also be used with gear and ratchet for bars up to 1 in. diameter. The machine is made in a larger size also to bend cold bars up to $1\frac{1}{2}$ in. diameter.

Matthew Wylie & Co.—The accompanying illustrations show moulds for pavement slabs and for sewer and drain pipes.

The *pavement slab mould*, known as the "Ideal," is used for making flagstones or pavement slabs, 36 in. long, 24 in. wide, and 4 in. high.

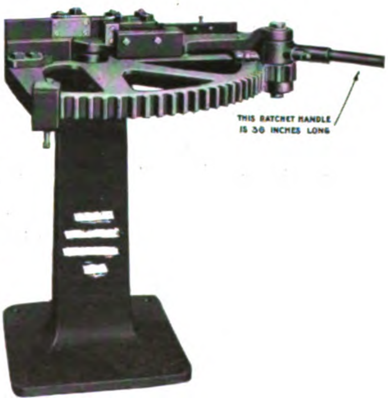
Sewer and drain pipe mould. The use of moulds for concrete pipes greatly facilitates their manufacture. It is important that the concrete should not be wet, but simply moist, as otherwise it sticks to the shell and gives trouble. In using the mould the pallet should be placed on the floor with the flat side up. The core is locked into this by suddenly pressing down the long rod lever to get maximum expansion, and then throwing forward the small lever by pressing it down tightly. The mechanism will be locked by compression. The outer casing is then brought round the pallet, locked in front, hoppers placed in position, when the mould is ready to be tamped full. Straight pipes, bell end pipes, and tongue and groove pipes can be made with this mould. Special moulds are required for Y and T connections.

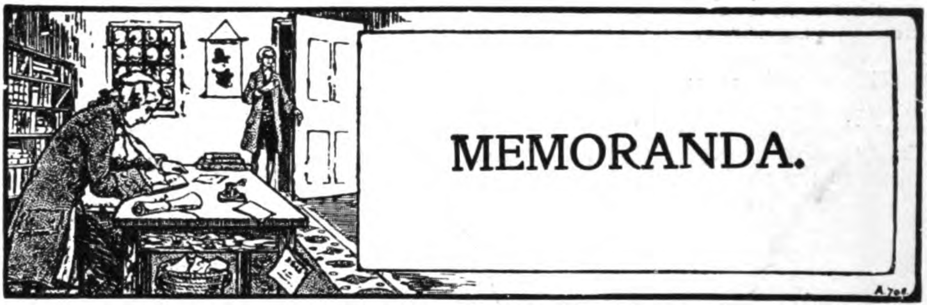




Other moulds made in addition to the above are lintel and step moulds, various ornamental moulds for garden work, such as vases, columns, balusters, etc.

Edward Le Bas & Co.—The *Hercules* bar bender here shown will bend twisted, corrugated, or any other reinforcement bars cold up to $1\frac{1}{4}$ in. thick. The ratchet handle, as indicated, is 36 in. long. The machine can be easily operated by one man. The ratchet lever operates pinion against a series of teeth in the frame at a ratio of 12 to 1. Dies are adjustable by means of set screws to suit the thickness of the bars to be bent.





MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Concrete Institute.—We have dealt with the opening meeting of the new session in another part of this issue. The Institute further announces that in view of the war the Council has decided to adjourn the matter of continuing educational lectures until a session subsequent to the forthcoming seventh session of 1914-15.

As a number of the junior members of the Institute will doubtless be engaged upon duties connected with the Forces, and consequently will be unable to attend the meetings of the Institute it has been thought desirable to discontinue, for the time being, the meetings of junior members which were commenced last session, unless there should be any general wish expressed for their continuance, in which case would those corresponding state whether they themselves would undertake to attend meetings regularly, in order that the probable attendance might be gauged?

The programme of lectures for the session 1914-15 is given below. The lectures take place on alternate Thursdays, at 7.30 p.m., and are as follows:—

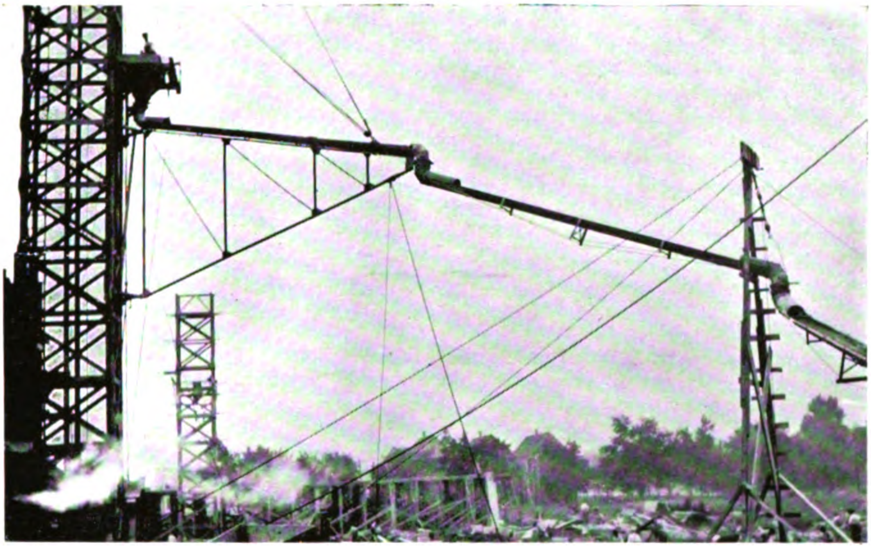
December 3rd.—Paper by Mr. H. Kempton Dyson (Secretary), on "Shear and Problems Arising Therefrom." *December 17th.*—Discussion on Report of the Science and Reinforced Concrete Practice Standing Committees on "A Standard Specification for Reinforced Concrete." *January 7th, 1915.*—Discussion on Report of the Joint Committee on Loads on Highway Bridges. *January 21st.*—Paper by Mr. Henry J. Tingle, M.Inst.C.E. (Member), on "The Application of Concrete in Modern Sanitation." *February 4th.*—Paper by Mr. Ewart S. Andrews, B.Sc. (Member), on "Some Modern Methods of Arch Calculation." *February 18th.*—Paper by Mr. T. A. Watson, Assoc.M.Inst.C.E. (Member), on "Economy in Reinforced Concrete Construction." *March 4th.*—Paper by Mr. R. Graham Keevill, A.M.I.Mech.E. (Member), entitled "Some Notes on Wind Pressure." *March 18th.*—Paper by Mr. Osborn C. Hills, F.R.I.B.A. (Member), District Surveyor for the Strand, on "The London Building Acts, with some Suggested Amendments." *April 8th.*—Continued Discussion on Mr. Hills's Paper. *April 22nd.*—Paper by Mr. F. E. Wentworth-Sheilds, M.Inst.C.E. (Vice-President), on "The Design of Quay Walls." *May 6th.*—Sixth Annual General Meeting and 62nd Ordinary General Meeting; Report of Council; annual election of Members of Council; award of Institute Medal; Paper by Mr. E. A. W. Phillips, M.Inst.C.E. (Member), on "Lime Concrete in the East." *May 20th.*—7.30 p.m., fifth Annual Dinner.

The meetings will be held in the Lecture Hall, at Denison House, 296, Vauxhall Bridge Road (close to Victoria Station), Westminster, S.W.

Fire Warnings for Farmers.—From the point of view of this Journal, there is an interesting feature in the Farmers' Fire Warning that is being so largely circulated in the agricultural districts by the British Fire Prevention Committee.

For the first time, in a publication of this description, reference is made to concrete fence posts. In suggesting the precaution of fencing round stackyards and ricks, it is pointed out to the farmer that the fence posts should either be heavy wooden posts or concrete posts. With the present price of timber, it would certainly be a great advantage in most districts to use concrete posts. Whatever the first cost may be, there is always the subsequent economy in maintenance and the greater strength of concrete posts.

Modern Concrete Chutes.—The accompanying illustration shows the application of a unique form of concrete chute designed at Chicago, Ill. The first section of the chute is supported on a steel "A" frame boom, which also supports the upper end of the second section.



It is pointed out that these two sections, that is, the first or boom section and the second section, together with the boom and receiving hopper, are mounted together on a frame and are raised or lowered on the tower as a unit. It is stated that the two sections may be followed by as many additional trussed sections as are required. They are connected together with universal elbows, which permit each section to swing in a complete circle and also allow a vertical play of about 18 ft. for each section. The trough of the chute is a half circle, being 14 in. wide on top.

It is of interest to note that these chutes are constructed with a 32-ft. boom and 32-ft. trussed sections, also with 50-ft. boom and 50-ft. trussed sections. It may be seen that the apparatus works like an old-fashioned gas jet. In other words, one can reach any point in the building or job within the radius of the chute with the minimum of labour and time. A wooden tower is used, no special tower being necessary. Special chuting equipments have been developed for special work, such as dam and bridge work, retaining walls, track and elevation work, along similar lines for distributing concrete mixture wherever desired.

Reinforced Concrete Shelter Sheds on an Australian Railway.—It is reported in the *Engineering News*, by Mr. R. E. Sexton, Engineer in Charge of Construction of the Railway Department of Queensland, Australia, that it was found some time ago that great expenditure was involved in the maintenance branch of the railway for the upkeep of the wooden structures used for shelter-shed accommodation, and, with a desire for a more economical method of construction, it was decided to erect reinforced concrete sheds in place of the wooden structures. Designs were prepared on the unit system with a view to facilitating erection and carrying out extensions in the quickest manner with a minimum of labour.

Piers or dwarf walls were erected under the building for the reception of the superstructure according to the requirements of the site. Beams reinforced with 1½ in. rods were then placed in position. These piers are holed to receive the reinforced concrete verticals of the side and end wall. The verticals are rebated on each side for the reception of 4 ft. by 2 in. by 18 in. wall slabs, rough-cast on the outside, reinforced with netting, the reinforcing rod at the top of the vertical being extended to such length as required to receive the wooden plate placed for the reception of the rafters of the roof, and the rods at the bottom of the vertical being bedded in the floor beams. The floor is of concrete 4 in. thick, reinforced with rods as required, and made in 4 ft. squares. The roof was constructed of wood and covered with tile. The cost does not exceed that of a wooden structure of corresponding size.

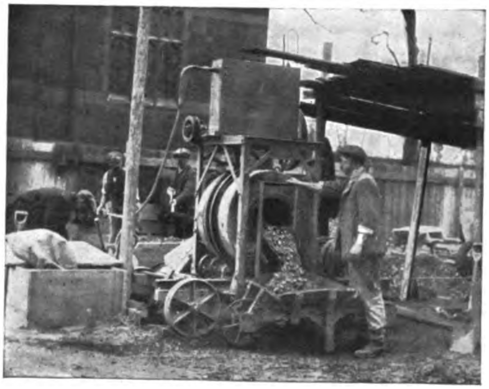
TRADE NOTICES.

Monnoyer System of Reinforced Concrete Chimney Construction.—Messrs. Edmond Coignet, Ltd., of 20, Victoria Street, S.W., inform us that they have made special arrangements to represent the Monnoyer system in this country. It has been extensively used on the Continent for chimney shafts, water condensers, and other similar works. The system consists of building up works by means of reinforced concrete segments prepared in moulds on the ground. The advantages claimed are resistance, lightness, and economy, due to the fact that no staging or shuttering are required. Anyone desirous of full particulars should apply to Messrs. Coignet at the above-mentioned address.

Lantern Slides for Lectures.—Messrs. Edward Bennis and Co., Ltd., inform us that they have a number of lantern slides dealing with the development of mechanical stoking, elevating and conveying apparatus, which they will be pleased to loan to any responsible engineer for lecture purposes. A list of the slides and particulars of their subject matter can be obtained on request. Applications for the loan of slides should be made well in advance of the lecture date and should be addressed to the Publicity Dept., 28, Victoria Street, S.W.

Claridge's Patent Asphalte Co., Ltd., have found it necessary, owing to their increasing trade in asphalte, to move to more commodious premises. Their new offices are No. 3, Central Buildings, Westminster, S.W.

They have also entered into another business—that of tarred slag macadam—under the title of Clarmac Roads, Ltd., which were started with works at Bilston, and further properties have since been acquired at Chatterly, in Staffordshire.



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